ON THE ADVANCEMENT OF SCIENCE BY PUBLISHED PAPERS

Undoubtedly science is kept alive by teaching; and without good teaching, there can be but little discovery. Edison, for instance, when young, possessed and studied Faraday's masterly researches on electricity.

The present writer has been engaged in scientific research for eighteen years or so. He does not pretend, however, to have observed all the following rules, of the importance of which he became cognizant by degrees. The foundation of the co-operative fabric of science and scientific discovery has been built up, by the work of the early "missionaries of science," when research entailed more or less of a martyrdom. It is hoped that we can pass on to posterity this edifice of science, undecayed and even embellished, now that research is a privilege and a giver of prestige. If we do not, the position of science and scientific work may deteriorate without limit.

(1) The truth, and nothing but the truth, but never the whole truth *for publication*. One must omit trivialities. Our scientific magazines are now sometimes more or less packed with never-to-be-utilized details, most of which perhaps would have better rested in the notebook. The penalty for nonobservation of this rule is the, probably now imminent, cessation of publication, except in the form of abstracts.

(2) It is perhaps unethical for a research worker, as for a medical man, to advertise. Plethoric papers, pictures not absolutely necessary, repetitions in different magazines, references mainly to one's own work, and unneeded elaboration or enlargement of figures, seem to partake of the nature of advertising. The penalty for infraction is the introduction of competitive business methods into science as an ideal; instead of the co-operative aims, which have produced such good results in the past.

(3) Mere facts, however new, are often (though not always) of perceptible scientific value only when their discoverer, or some one else, has demonstrated their relations to other facts, or to a theory or hypothesis of value. If they have no such demonstrable relations, they are probably "trifling though true." The penalty is again the ending of magazine publication *in extenso*.

(4) The repetitions and confirmations of a discovery on similar or related material are of sufficient scientific interest to warrant full publication only to a certain degree of repetition. Whether this is ten or a hundred times, the point is at length reached when only the accounts of exceptions to the rule are worth full publication. The penalty is again the flooding of magazines, and the future reduction to abstract publication.

(5) The publication of a working hypothesis by one who has discovered a sufficient amount of relevant fact is welcome, and indeed almost necessary. (A working hypothesis is one that is immediately to be tested.) But a mass of untested hypotheses is readily producible; and may be aimless, except to fill space. A flood of hypotheses, which cannot be immediately tested, may be a brake on the progress of a science. Since it is easier, for many of us, to spin hypotheses than to make discoveries, the penalty for the appreciation and prestige of this form of mental exercise is the partial, or even complete, cessation of experiment.

(6) It is probably unethical to claim credit or priority for an untested hypothesis (mostly for writers in the distant past), to the prejudice of those who have borne the full burden of testing it. A writer who has published, among a number of unworkable hypotheses, one which has subsequently been used as a successful working hypothesis, does not apparently deserve to be cited. Perhaps one should not attach priority to any untested hypothesis, but only to true working hypotheses.

(7) It is generally recognized that, in a serious scientific paper, citations of a genuinely relevant previous work should be complete, so far as they are not known to all readers. Even excessive and pedantic citation is a fault on the right side. But surely much space might be saved by referring to standard numbered annual lists of scientific papers. The penalty for lack of citation is, of course, to leave it doubtful as to how much the writer has himself discovered. It leads also to the isolation of workers or countries. But excessive citations again overload the magazines.

(8) A form of scientific co-operation consists in the sending of separate copies of papers, in not readily accessible magazines, to other interested workers. This has now extended to all magazines, even those accessible to everybody. Stanley Hall regards it as a means of working up a personal following or constituency; in other words, it is now an advertising method. Perhaps as much as anything else, it injures the circulation of the scientific magazines.

These and other similar rules are, of course, well known to, and observed by, many experienced workers.

—NATURE.

Agriculture, more than any other industry today, feels a widespread need of capable, intelligent and clear thinking leaders, such as might be developed from high school students who choose to take an agricultural college course.

—*Quarterly of Alpha Zeta.*

THE CORN BORER, PYRAUSTA NUBILALIS HÜBNER (PYRALIDAE, PYRAUSTINAE, LEPIDOPTERA)[1]

CATALINO T. BULIGAN

WITH EIGHT PLATES

INTRODUCTION

General statement of the problem

The corn borer, *Pyrausta nubilalis* Hübn., is one of the worst enemies of corn in the Philippines. The work of the larvae causes breaking of the stalks in a heavy wind, destruction of the silk, and failure of ears to mature.

Damage to corn in the field is often considerable. Infested plants produce few marketable ears or none at all, and, in some localities, fifty per cent or over of the season's crop is destroyed. The pest then is of great economic importance, especially in view of the fact that corn constitutes the principal staple food in some regions of the Philippines, notably among the working classes of the Ilocano and Visayan provinces.

Systematic position

Through the courtesy of Mr. Carl Heinrich and Mr. D. W. Jones, of the United States Bureau of Entomology, the pest under discussion has been determined as identical with the well-known European corn borer in the United States and Europe, *Pyrausta nubilalis* Hübner (Pyralidae, Pyraustinae, Lepidoptera). According to Mr. Heinrich, *P. vastatrix* Schultze, under which name the corn borer as it occurs in the Philippines is usually known, is apparently a synonym. He reports in part that "if the specimens in the [U. S. National] Museum collection are properly determined, the following will have to be listed as synonyms of *P. nubilalis: polygoni* Dyar, *demoalis* Walker, *vastatrix* Schultze, and *furnacalis* Guenee."[2] Caffrey and Worthley (1927) list the following as synonyms of *Pyrausta nubilalis:*

Pyrausta silacealis Hübner
Pyralis glabralis Haworth
Botys silacealis Freyer
Botys lupulinalis Guenee
Botys zealis Guenee
Botys nubilalis Lederer
Botys lupulina Heinemann
Hapalia kasmirica Moore
Hapalia lupulina Butler
Pyrausta nubilalis Meyrick
Pyrausta polygoni Dyar
Pyrausta vastatrix Schultze

[1] Thesis presented for graduation, 1928, with the degree of Bachelor of Agriculture from the College of Agriculture No. 275; Experiment Station contribution No. 563. Prepared in the Department of Entomology under the direction of Associate Professor Leopoldo B. Uichanco.

This thesis was awarded the Class of 1925 Medal for best thesis presented in 1928.

[2] Quoted in letter from D. W. Jones, Arlington, Massachusetts, U. S. A., May 24, 1926, to whom a series of adult specimens from the Philippines had been sent.

Bred adults of *Pyrausta nubilalis* have been found to vary considerably in color shades and patterns.

Review of previous work

In the Philippines. Corn borer has not been adequately studied in this country. Banks (1906), Jones (1913), and Navarro (1911) were among the earliest to record it as very destructive to corn. Woodworth (1921) reported sorghum, millet, and *Panicum* spp. as additional hosts. Schultze (1908) described the adults, and, as noted above, wrongly assigned them to a new species, *Pyrausta vastatrix.*

In other countries. The United States has probably done more than any other country in working out the biology of this pest. It is an imported pest in the Western Hemisphere, having been introduced first into the United States and Ontario, Canada, through shipments of broom corn in 1909 and 1910 (Caffrey and Worthley, 1920). It was first discovered in the United States in 1916 (Huber and Neiswander, 1927). Caffrey and Worthley (1920) report that this species was first identified from Boston, Massachusetts, during the summer of 1917. At that time, the insect was found to be present within an area of at least 100 square miles in the vicinity of Boston. The direction of spread is uncertain, but, according to the report of Caffrey and Worthley (1927), infestation by this pest was discovered at Scotia, New York, in January, 1919; at North Girard, Erie County, Pennsylvania in September, 1919; at the Pennsylvania towns bordering Lake Erie and most of the townships bordering the latter lake in Ohio and Michigan, and also on the islands in the western end of the lake in 1921. The spread has been so rapid, in spite of all safeguards undertaken, that in 1925 the infested area in North America was estimated at 80,609 square miles (Drake, 1926). There has been in operation for several years, as a branch of the United States Bureau of Entomology, an European corn borer laboratory at Arlington, Massachussetts. This station is mainly concerned with importation of corn borer parasites from abroad, and propagating and liberating them in infested areas. Writing in 1925, Caffrey reports that up to that time 1,168,276 introduced parasites had been set free. These consisted of seven species; namely, *Zenillia roseanae* B. et B., *Eulimnerea crassifemur* Thom., *Angitia punctoria* Roman, *Habrobracon brevicornis* Wesm., *Exeristes roborator* Fabr., and *Phaeogenes planifrons* Wesm.

Wade (1925) published a comprehensive bibliography of the European corn borer, which consists of some 900 titles mainly from the pen of European and American entomologists. The earliest paper in the list was published in 1812.

Geographical distribution

Pyrausta nubilalis is practically a cosmopolitan species. It has been reported from all the zoögeographical regions, except the Australian and

the Ethiopian. It is, however, known to occur in Egypt, which, although Palaearctic, is not very far from the Ethiopian region.

The pest is of recent introduction in the Western Hemisphere, so that the original home is presumably somewhere in the Old World. It follows, therefore, that corn, which is a native of America, is not the original host, but has been secondarily acquired on the introduction of this crop into the Eastern Hemisphere. Huber and Neiswander (1927) believe that the probable original food plant of this insect was the wild hop.

The following list gives the countries wherein *Pyrausta nubilalis* has been recorded. They are grouped in their respective zoögeographical regions, as established by Sclater and Wallace:

Nearctic Region

Countries	*Authorities*
United States	Adkins (1919)
	Atwood (1919)
	Babcock (1924)
	Britton (1919a, 1919b, 1919c, 1921, 1923, 1924, 1925)
	Barber (1924a, 1924b, 1924c, 1925a, 1925b, 1925c, 1925d)
	Bourne and Fernald (1919)
	Bauer, Flint, and Hackleman (1923)
	Caffrey (1919a, 1919b, 1924, 1925)
	Caffrey and Vinal (1919)
	Caffrey and Worthley (1922, 1927)
	Cotton (1921)
	Dean (1925)
	Drake (1926)
	Felt (1919a, 1919b, 1919c, 1919d, 1919e, 1919f, 1920a, 1920b, 1921a, 1921b, 1921c, 1921d, 1922, 1923)
	Fernald (1918)
	Flint and Malloch (1920)
	Hadley (1925)
	Haseman (1920)
	Heinrich (1919, 1921)
	Holloway (1921)
	Howard (1919a, 1919b, 1921, 1922)
	Houser (1919)
	Huber and Neiswander (1924a, 1924b, 1924c, 1925, 1927)
	Hyslop (1922)
	Jones (1924)
	Keenan (1922)
	Lyle (1924)
	Mackie (1923)
	Marlatt (1919a, 1919b)
	Mosher (1919a, 1919b)
	Osborn (1926)
	Parks (1924, 1926a, 1926b)
	Pettit (1920a, 1920b, 1925a, 1925b)
	Reynolds (1919)
	Roberts (1919)

	Severin (1922)
	Smith (1920, 1923)
	Thatcher (1925)
	Thompson, M. C. and W. R. (1921, 1923)
	Thompson, W. R. (1922)
	Vinal (1917)
	Wade (1925)
	Wallace (1922)
	Walton (1920, 1921)
	Woodbury (1919)
	Worthley (1924, 1926)
Canada	Baird (1924)
	Caesar 1922, 1923, 1924a, 1924b, 1924c, 1925)
	Crawford (1921, 1923a, 1923b, 1924)
	Crawford and Spencer (1921, 1922a, 1922b, 1923)
	Crawford and McLaine (1925, 1926)
	Felt (1919c)
	Ficht and Painter (1924a, 1924b)
	Gibson (1920)
	Keenan (1920, 1922, 1923)
	Lochhead (1920)
	McLaine (1919, 1920, 1921a, 1921b, 1922a, 1922b, 1923, 1924)

Neotropical Region

Countries	*Authorities*
Argentina	Sobrero (1924)

Palaearctic Region

Countries	*Authorities*
Portugal	Mendes (1913) [3]
British Isles (U. K.)	Barrett (1875) [3]
France	Genieys (1922)
	Lesne (1920) [3]
	Marchal and Foex (1918, 192?)
	Marchal (1914) [3]
	Noel (1917a, 1917b)
	Poutiers (1922)
	Rives (1919)
	Vuillet (1913, 1919)
Holland	Picquendaele (1910)
Belgium	Picquendaele (1919)
Germany	Caffrey (1925)
	Picquendaele (1919)
Hungary	Bako (1917a, 1917b)
	Kadoosa (1923)
	Caffrey (1925) [3]
	Emich (1894) [3]
	Fabricius (1914) [3]
Europe (Central and Southern)	Drake (1926)
	Felt (1920a)
	Vinal (1917)

[3] From Wade (1925)

Russia	Anutchin (1918)[3]
	Dobrodeiv (1921)
	Dreier (1914)[3]
	Keshkovsky (1918)
	Kostinsky (1915)[3]
	Krassilstchik (1915)[3]
	Kurdiumov (1914)[3]
	Miller (1915)[3]
	Paczoski (1916)
	Uvarov (1917)
	Vassiliev (1917)
	Vereshtchagin (1922)
	Zvierezomb-Zubovsky (1918, 1920)
Egypt	Andres (1913)[3]
Asia (Central and Northern)	Drake (1926)
	Felt (1920a)
	Vinal (1917)
China	Drake (1926)
Japan	Drake (1926)
	Felt (1920a)
	Takahashi (1919)
	Vinal (1917)

Oriental Region

Countries	*Authorities*
India	Hampson (1896a)
Philippine Islands	Jones (1913)
	Navarro (1911)
	Schultze (1908)
	Woodworth (1921)
	In addition to the present report

Oceanic Islands (unclassified)

Countries	*Authorities*
Guam	Griggs (1919, 1921a, 1921b, 1922)

Object of the present work

The object of the present work was to study the biology of *Pyrausta nubilalis* with the end in view of finding methods of control applicable under Philippine conditions.

Time and place of the present work

Experiments were begun in October, 1924 and carried through December, 1926. The work was conducted in the fields and in the entomological laboratory of the College of Agriculture, University of the Philippines, Los Baños, Laguna.

MATERIALS AND METHODS

Insectary methods

Life history observations. Larvae and pupae collected from the field were kept in mass cultures in battery jars; the pupae in separate jars from

[3] From Wade (1925)

the larvae. Fresh portions of corn stalk were supplied regularly to the larvae as needed, and the old feed removed. It was found in the course of the work that it was not necessary to renew the stalks more than twice a week. Pairs of one male and one female which emerged from the larvae were isolated in small, wide-mouthed bottles which were stoppered with a thick wad of cotton. A fresh cotton pellet moistened with water was supplied daily to the moths. The cultures were inspected in the morning for eggs, and moths that were found to have oviposited were transferred to another bottle. All bottles were carefully labelled so as not to confuse the different cultures.

Newly hatched larvae were isolated individually in cotton stoppered vials and supplied with a piece of fresh corn stalk, which was renewed daily. Each vial was given a number for convenience in recording instars and other biological data.

Anatomical material, consisting of eggs, different larval instars, and pupae were fixed in water at 80°C. for from five to ten minutes, pricked and then preserved in 70 per cent alcohol. Adults were mounted on pins.

Collection of parasites. Eggs brought in from the field were kept in vials, so as to secure egg parasites. Parasites of larvae and of pupae were collected from the mass cultures used in breeding out adult moths. Predators were gathered from the field.

Field observations

Regular field inspection at least once a week was made in an effort to determine seasonal occurrence and abundance, nature of damage in the field, alternative host plants, places of oviposition in nature, habits of the insect in each of the various stages, and other biological field data.

This phase of the work covered practically the entire campus of the College of Agriculture and vicinity. Observations of corn fields were started when the plants were seedlings and continued up to maturity of the crop. Infested corn plants were closely examined to determine the nature of the damage, places of oviposition, habits of the insect in each of the various stages, and natural enemies of the pest. Several corn plants bearing egg masses on the leaves were tagged and observed closely for the behavior of the larvae after hatching.

Field inspection was eventually extended to the examination of other species of plants (both cultivated and wild). The object was to determine the alternative hosts of the corn borer. Any plant found attacked by boring insects was examined. Those borers which were hardly distinguishable from the larvae of *Pyrausta nubilalis* were brought to the insectary and bred to the adult stage.

RESULTS AND DISCUSSIONS

Description

Adult male (pl. 6, fig. 34). Length (based on sixty-eight specimens) 8 to 14 millimeters, average 11.6; width 1.3 to 3, average 2; expanse of

wings 20 to 28, average 25.5; length of fore wing 9 to 12, average 11.3; width 4.5 to 6, average 5.5; length of hind wings 7 to 9.5, average 8.5. General color, yellowish ochraceous, varying from light to dark (adults reared during dry season darker than those reared during rainy season). Body yellowish ochraceous dorsally and pale stramineous ventrally. Eyes black. Legs pale yellow. Fore wing ochraceous, with characteristic markings as follows: a brownish ochraceous band, occupying about one-third total area of wing, extending from anal margin to costal margin, midway between extremities of wing at a distance of about one-third total length of latter from either humeral angle or apical margin of wing, with dark ochraceous, narrow, very sinuous border anteriorly, a subtriangular ochraceous area on posterior half of discal cell, with a dark ochraceous spot at short distance from anterior angle, and bordered by dark ochraceous line posteriorly; posterior margin serrately sinuous; a second dark ochraceous band extending from anal margin to costal margin of wing and occupying about one-fourth total length of latter posteriorly, with series of irregular lengthwise ochraceous lines; anterior margin diffuse; posterior margin flush with apical margin of wing. Hind wing yellowish stramineous, an ochraceous band which occupies about one-fifth total length of wing posteriorly. Posterior margins of abdominal segments bearing conspicuously paler yellowish white scales than rest of body.

Head (pl. 6, fig. 37) suboval from anterior aspect, about two-thirds as long and as wide as mesothorax. Eyes subspherical, occupying about two-thirds total area of head. Frons subrectangular, about one-third as wide as total breadth of head. Vertex subtrapezoidal from dorsal aspect, about as long as broad, bearing two ocelli, which are subspherical and situated posterior to base of antennae, about as broad as apical segment of antennae. Antennae (pl. 7, fig. 38) filiform, about one and one-fourth times as long as total length of body, located dorsal to compound eyes, moderately covered with scales, segments varying from 60 to 62 in number; basal segments on the average about one-half as long as broad, about two-thirds as long as and three times as broad as distal segments; distal segments about twice as long as broad; apical end of terminal segment bearing three cylindrical spines. Labial palpi porrect, densely covered with scales, about one and one-half times as long as diameter of eyes, situated ventrally with respect to maxillary palpi, three-segmented; I subellipsoidal, attenuate basally, about twice as long as broad, about two-fifths as long as II; III subfusiform, about as wide as I, slightly tapering distally; III subellipsoidal, about three times as long as broad and about one-half as broad as II. Maxillary palpi porrect, densely covered with scales, about one and one-fourth times as long as and two-fifths as broad as segment I of labial palpi, about one-fifth as broad as long, four-segmented; I about one-half as long as broad; II about as long as wide, about one and one-half times as long as and three-fourths as wide as I; III subcylindrical, rounded at both ends, about as

broad and one and one-third times as long as II; IV suboblong, about as long as III, about two-thirds as broad as long. Maxillae (proboscis) moderately covered with scales basally, about four-fifths as long and two-thirds as wide as antennae.

Thorax subcylindrical, about one-fifth total length of body. Prothorax about one-third as long and about two-thirds as wide as head; patagia subfusiform, unsegmented, densely covered with scales, attached to prothorax laterodorsally, about one-third as broad as prothorax and about four times as long as wide. Mesothorax about as long as wide, about six times as long and twice as broad as prothorax; tegulae finger-shaped, densely covered with long scales, attached to anterior portion of mesothorax laterodorsally, about one-fourth as broad as mesothorax, and about one-third as broad as long. Metathorax tapering posteriorly, about three-fourths as long and three-fourths as wide as mesothorax, about two-thirds as long as broad. Fore wing (pl. 7, fig. 39) about two and one-half times as long as broad, about one and one-third times as long and five-sixths as broad as hind wing. Discal cell elongately subtriangular, about five times as long as broad distally, about one-half as long and one-fourth as broad as wing; proximal angle describing about 15 degrees. C about two-thirds as long as costal margin of wing; cell C narrowly subelliptical, about one and one-tenth times as long and one-fourth as broad as discal cell, about twenty-two times as long as wide; Sc about as long as C, curving subdistally toward costal margin, meeting latter at about one-third length of costal margin from apical angle of wing; cell Sc about one-fourth as broad and one and one-fifth as long as discal cell, subuniform in width throughout, curved subdistally toward costal margin; R about two-thirds as long as Sc, branching midway between base and apex of wing into R_1 and R_s: R_1 about four-fifths as long as R, describing an angle with R_s of about 13 degrees, slightly curving toward costal margin and meeting latter at a distance of about two-sevenths length of wing from apex of latter; cell R_1 subtriangular, about four-fifths as long and two-thirds as broad as discal cell, about one-third as broad as long; R_s about one-fourth as long as R, branching at ectodistal angle of discal cell into R_2 and R_4; R_2 about as long as R_1, about one-half length subbasally coalescent with R_4, curving toward costal margin and meeting this margin approximately midway between distal end of R_1 and apex of wing; cell R_2 subtrapezoidal, about one-fourth as broad as long, about four-sevenths as long and two-thirds as broad as cell R_1; R_3 about one-third as long as R_2, branching out from R_4 at about three-eighths length of latter from apex of wing, describing an angle of about 19 degrees with R_4, meeting costal margin about midway between R_2 and apex of wing; cell R_3 subtriangular, tapering proximally, about one-fourth as broad as long, about five-sevenths as long and three-fourths as broad as cell R_2; R_4 about four times as long as R_3, slightly curving basally toward R_5, coalescent basally with R_5 at ectodistal angle of discal cell and describing an angle of about

14 degrees, terminating at apex of wing; cell R_4 elongately subtriangular tapering proximally, about one-eighth as broad as long, about four-fifths as long and two-thirds as broad as discal cell; R_5 about as long as R_4, slightly curved, subparallel to costal margin, extending from base of discal cell to apical margin of wing, meeting this margin at a distance of about three-fifths of vein R_3 from apex to anal angle of wing; cell R_5 elongately subrhomboidal, tapering proximally, about one-seventh as broad as long, about as long and as broad as cell R_4; veins R_5, M_1, M_2, M_3, Cu_1, and Cu_2 terminating at apical margin of wing, subequidistant; M_1 slightly shorter than R_5, connected to R_5 by distinct radiomedial cross-vein (r-m), which is about one-tenth length of R_3; cell M_1 elongately subrectangular, about seven times as long as broad, about as broad as cell R_5 and slightly shorter than the latter; M_2 subparalled to M_1, slightly shorter than the latter, about seven-eighths as long as R_4, originating from discal cell and connected basally with M_1 by discal vein (d), which is about four and one-half times as long as cross-vein r-m; cell M_2 rhomboidal, tapering basally, proximal margin about one-fourth as long as distal margin, about one-seventh as broad as long, about three-fourths as broad and fourteen-fifteenths as long as cell R_5; M_3 subrectilinear, slightly shorter than M_2, originating from discal cell at entodistal angle of this cell, connected basally with M_2 by medial cross-vein (m), which is about one-fourth the length of discal vein (d); cell M_3 subtrapezoidal, tapering basally, about one-seventh as broad as long, about as long and one and one-third times as broad as cell M_2; C_1 (cubitus 1) curving abruptly along discal cell, deflected entobasally at an angle of about 155 degrees and connected to M_3 by mediocubital cross-vein (m-cu), which is about two and two-thirds times as long as medial cross-vein (m), from point of curvature to base of Cu_1, about one and one-third times as long as M_3, branching with Cu_2 from a principal vein Cu at ental margin of discal cell at a distance of about one-half length of vein M_2 from base of latter to proximal angle of discal cell; cell C_1 subtrapezoidal of almost uniform breadth, about one-seventh as broad as long, about as broad and one and one-third times as long as cell M_3; Cu_2 subrectilinear, slightly shorter than Cu_1, subparallel to Cu_1, describing an angle of about 20 degrees with basal portion of vein Cu_1 along ental margin of discal cell; cell $Cu+Cu_2$ subtrapezoidal, about one-eighth as broad as long, about one and five-eighths times as long and two-thirds as broad as cell Cu_1; Cu about four-fifths as long as vein Cu_2, bordering proximally along ental margin of discal cell; 2A slightly arcuate toward anal margin, describing proximally with Cu an angle of about 16 degrees, about one and one-half times as long as Cu_2, terminating at anal angle; 3A about one-half as long as 2A, very close to 2A basally, curving toward anal margin and nearly reaching this margin, then bending toward 2A and meeting the latter at a distance of about five-elevenths length of 2A from base of latter; cells 1st 2A and 2nd+3A together describing a narrowly subelliptical figure, about ten times as

long as broad, about one and one-fifth times as long and three-fourths as broad as discal cell. Cell 1st 2A about five times as long as broad, about five-twelfths as long and three-fourths as broad as 1st 2A+2nd 2A+3A, distinctly separated from 2nd 2A+3A by vein 3A. Hind wing (pl. 7, fig. 40) about one and three-fourths times as long as broad, bearing a single frenulum; consisting of one stout long slightly curved spine, about one-fifteenth as broad as long, about one-fifth as long as total length of wing. Discal cell subtriangular; distal margin emarginate and bordered by discal vein (d); ectal margin about two-thirds as long as ental margin; proximal angle about 30 degrees; about twice as long as broad; about one-third as long and one-fourth as broad as wing. Cell C elongately narrowly subelliptical, about fifteen and one-half times as long as broad, about six-sevenths as long and one-tenth as broad as wing; Sc originating near base of frenulum, uniting with R beyond discal cell to form vein $Sc+R_1+R_s$; cell Sc elongately subtriangular, about one-twelfth as long as broad basally, about three-sevenths as long and four-sevenths as broad as cell C; $Sc+R_1+R_s$ about two-sevenths as long as Sc, branching into veins $Sc+R_1$ and R_s; $Sc+R_1$ about two and one-fifth times as long as $Sc+R_1+R_s$, describing an angle with R_s of about 13 degrees, extending toward costal margin and meeting the latter at about the length of $Sc+R_1+R_s$ from apical angle of wing; cell R_1 elongately subtriangular, about one-seventh as broad as long, about as long and twice as broad as cell Sc; R_s about one and one-fourth times as long as $Sc+R_1$, subparallel to costal margin; cell R_s elongately subtriangular about nine times as long as broad, about as broad and one and two-thirds times as long as cell R_1; R about as long as Sc, bordering ectal margin of discal cell, meeting vein $Sc+R_1+R_s$ beyond this ectal margin; M_1 about one and one-half times as long as R_s, originating from discal cell, describing an angle of about 18 degrees with distal end of R, extending distally and meeting apical margin at about one-fourth length of $Sc+R_1$ from apex of wing; cell M_1 subtrapezoidal, about one-sixth as broad as long, proximal margin rounded and bordered with discal vein which is about one and four-fifths times as long as distal margin, about as broad and twice as long as discal cell; M_1, M_2, M_3, Cu_1, Cu_2, and 1A subequal in degree of curvature, subequidistant distally; M_2 subparallel to R_s, about five-sixths as long as M_1, originating from discal cell at entodistal angle of it; cell M_2 elongately subtriangular, tapering basally, about four times as long as broad, about five-sixths as long and about one and one-fourth times as broad as cell R_s; M_3 slightly shorter than M_2, originating close to base of latter and basally describing an angle with M_2 of about 13 degrees, connected to Cu_1 by mediocubital cross-vein (M-Cu), which is about one-tenth as long as Cu_1; cell M_3 elongately subtrapezoidal, slightly tapering basally, about one-seventh as long as broad, about as broad and one-seventh as long as cell M_2; Cu_1 about as long as M_3, branching along ental margin of discal cell with Cu_2 at about one-third the length

of M_3 from base of latter; cell Cu_1 elongately trapezium-shaped, tapering basally, about as long and as broad as cell M_3; Cu_2 about five-sixths as long as Cu_1, describing an angle with Cu_1 basally of about 16 degrees; Cu about one-half as long as Cu_2, bordering two-thirds ental margin of discal cell; cell $Cu+Cu_2$ elongately subtrapezoidal, tapering basally, about ten times as long as broad, about as broad and one and one-half times as long as cell Cu_1; 1A less prominent than other veins, originating close to base of Cu and describing an angle with Cu of about 9 degrees, about one and one-third as long as Cu_2; cell 1A subtrapezoidal, tapering basally about six times as long as broad, about as long and as broad as cell M_1; 2A about ten-twelfths long as 1A, terminating on anal margin at about two-thirds length of Cu from distal end of 1A to anal margin of wing; cell 2A elongately subtrapezoidal, tapering basally, about eight times as long as broad, about four-fifths as long and two-thirds as broad as cell 1A; 3A about four-fifths as long as 2A, slightly curving toward anal margin, meeting this margin at about a distance of one-half length of Cu from distal end of 2A; cell 3A narrowly subhemiellipsoidal, about nine times as long as broad, about one-half as long and one-half as broad as cell C. Fore leg (pl. 7, fig. 41) about as long as total length of body; coxa elongately subconoidal, about one-fifth as long as total length of leg, about one-third as broad as long; trochanter subtriangular, length subequal to width of coxa; femur subfusiform, about one and two-fifths times as long and two-thirds as wide as coxa; tibia subcylindrical, slightly tapering distally but more markedly so basally from middle, about three-sevenths as long and two-thirds as broad as femur, an ental spur midway between extremities; spur about one-half as long as tibia, densely covered with scales and tapering distally; tarsus about three times as long as tibia, five-segmented; segments subcylindrical, I (metatarsus) about one and one-fourth times as long and about two-thirds as broad as tibia; II about two-thirds as broad as and two-fifths as long as I, subequal length and width of either III, IV, or V, which are of nearly the same dimensions; claws stout, sharply pointed, arcuate ventrally, about one-fourth as long and one-third as broad as V, about twice as long as broad. Middle leg (pl. 7, fig. 42) about one and one-sixth times as long as fore leg; coxa subconoidal, about one-eighth as long as total length of leg, about two-thirds as wide as long; trochanter subcylindrical, about one-third as long as coxa; femur subfusiform, about one-fourth as long as total length of leg, about two-thirds as broad as coxa; tibia subcylindrical, tapering basally, about one and one-sixth times as long and two-thirds as broad as femur, unequal entodistal spurs; larger spur about twice this size of the smaller, about two-fifths as long and two-sevenths as broad as tibia; tarsus about as long as tibia, five-segmented; each segment subcylindrical, bearing two short entodistal spurs with exception of V; I (metatarsus) tapering basally, about one-third as wide and two-fifths as long as tibia; II about one-half as long and as broad as I; III about two thirds length and two-thirds

width of II; IV about one-half as long and one-half as wide as III; V about as long and as broad as IV; claws subequal to those in fore legs. Hind leg (pl. 7, fig. 43) smaller than middle leg, about one and one-eighth times as long as total length of fore leg, subequal in length to middle leg; coxa subconoidal about one-eighth as long as total length of leg, width about two-thirds length; trochanter subconoidal, about one-third length and one-third width of coxa; femur abruptly subfusiform, tapering basally and distally from middle, about twice as long and two-thirds as broad as coxa, two-elevenths as long as total length of leg; tibia subcylindrical, tapering basally about three-fourths as broad and one and seven-tenths as long as femur; two pairs of ental spurs as follows: first pair midway between extremities; second pair located entodistally, one of each pair about two-thirds the other; tarsus about one and one-fourth times as long as tibia, five-segmented, segments of subequal width and each, except V, bearing a short entodistal spur; I (metatarsus) tapering basally, about one-half as long as tibia; II about three-fifths as long as I; III about two-thirds as long as II; IV about one-half as long as III, subequal in length to V; claws subequal to those in fore legs.

Abdomen extending caudally beyond anal angles of fore wings, elongately subfusiform, tapering from segment III anteriorly and posteriorly; eight distinct segments; I about two-thirds as long as wide, about one-half as long as metathorax; II about one-third as long as broad, about as long and one and one-third times as broad as I; III about three-fifths as long as wide, about twice as long and as broad as II, subequal length of either IV, V, VI, VII, or VIII, which have about the same measurements; IV about three-fourths as long as broad, about eleven-twelfths as broad as III; V about four-fifths as long as wide, about eleven-twelfths as broad as IV; VI about four-fifths as long as broad, about as long and as wide as V; VII about one and one-fourth times as long as broad, about three-fourths as wide as VI, about one-half as broad as III; VIII about two-thirds as broad and as long as VII.

Male genitalia (pl. 7, fig. 44 and pl. 8, fig. 45) densely covered with long hairs, strongly chitinized, one and one-third times as long as and slightly narrower than abdominal segment VIII, about one-fourth length of it, extending caudally beyond distal margin of VIII; aedoeagus (pl. 8, fig. 46) subfusiform, moderately chitinized, about three and one-half times as long as broad, about one-fifth as broad and three-fourths as long as abdominal segment VII; penis (pl. 8, fig. 46 and 47) subcylindrical, membranous, lying within and occupying about four-fifths width and entire length of aedoeagus, about twice as long as aedoeagus when extended, apically with subcylindrical highly chitinized process, the vesica (Pierce, 1914, cited by Eyer, 1924); vesica about two-fifths as long and about one-half as wide as aedoeagus, attached to ventral wall of penis and situated just behind apex of aedoeagus. Vinculum **U**-shaped from ventral aspect, heavily

chitinized, about one and one-third times as long as broad, about one and one-third times as broad and one-third as long as aedoeagus; anellus membraneous, opening suboval, slightly broader than aedoeagus, bearing juxta and two projecting lobes which are each connected to harpe by a chitinized arm; juxta V-shaped, slightly chitinized, located on ventral surface of anellus, about two-thirds length and two-thirds width of vinculum; transtilla a strongly chitinized band about one-fourth as long as broad and as broad as anellus, one pair of posterolateral arms connecting harpes situated laterally with respect to clasper, and a second anterolateral pair extending to outer margin of anellus, subequal in size to first pair, tapering distally, about one-sixth as broad as long, the breadth about one-half the length of transtilla; harpes elongately scoopshaped, attached to posterior margin of vinculum, about three and three-fifths times as long as broad, about twice as broad and two and one-eighth times as long as aedoeagus, sacculus occupying about one-half of harpe basally; clasper highly chitinized with spinose oval face at distal end, situated nearly perpendicularly with respect to harpe, subconoidal, tapering basally, attached to sacculus entodistally, about two-thirds as long as broad, about two-thirds as bread and one-seventh as long as total length of harpe; appendiculate thorn strongly chitinized, about as broad and one and one-third times as long as transtilla, bearing one large and two smaller subequal stout spines; large stout spine about as broad and two-thirds as long as any of the arms of transtilla, about one and one-third times as long and likewise as broad as any of the two smaller spines, located anteriorly near base of clasper; cucullus elongate, occupying about one-half distal portion of harpe, about one and seven-tenths times as long as broad, sparsely beset with short bristles on inner surface and densely with long bristles at dorsolateral margin; tegumen membranous, elongately subconoidal, supported by two chitinized arms, which extend proximodistally at base of uncus, about twice as long as broad, about one-half as long as broad as harpe, uncus divided into three subequal lobes distally, crown-shaped from dorsal aspect, beset dorsally with stout bristles on two lateral lobes, about three-fourths as long as broad, about one and one-fifth times as broad as aedoeagus; anal opening situated at entodistal part of subcylindrical process; subcylindrical process inserted between uncus and tegumen, tapering distally, about as long and two-fifths as broad as aedoeagus.

Adult female (*pl. 6, fig. 35 and 36*). Length (based on sixty-eight specimens) 7 to 14 millimeters, average 11.6; width 2 to 4, average 2.5; expanse of wings 24 to 33, average 29.4; length of fore wings 11 to 16.5, average 19.9; width 5 to 7, average 6; length of hind wing 8.5 to 11, average 9.6. External morphological characters similar to male, with the following exceptions:

General color usually lighter. Body relatively larger and more robust.

Head about two-thirds as long as broad, about one-twelfth as long as total length of body.

Thorax subellipsoidal, about one-third as long as total length of body, about four times as long as head; prothorax about two-thirds as long as broad, about two-thirds as long and as broad as head; mesothorax about as broad as long, about four times as long and one and one-half times as wide as prothorax; metathorax tapering distally, about two-thirds as long and two-thirds as wide as mesothorax. Hind wing with frenulum consisting of two long spines and one short one; long spines subequal in size, stout, about one-fortieth as long as broad, about three times length and seven times width of smaller one, about one-fifth as long as total length of wing.

Abdomen subfusiform, very much less extended caudally beyond anal angles of hind wings than in male and comparatively more blunt distally; I about as long and two-thirds as wide as metathorax; about as long as either II, III, IV, V, or VI, which are subequal in length; II about one and one-third as broad as I, about one-half as long as broad; III about one-third as long as broad, about one and one-third times as wide as II; IV about one-third as long as broad, about one and one-sixth times as wide as III; V subequal length and width of IV, VI tapering distally, about twice as long as broad, about four-fifths as broad as V; VII tapering distally, about three-fourths as broad as long, about two-thirds as wide as VI; VIII about two-thirds as long as wide, about one-fourth as long as and one-third as broad as VII; IX about one-half as long as broad, about three-fourths as broad and three-fourths as long as VIII; X about two-thirds as long and two-thirds broad as IX.

Ovipositor (pl. 8, fig. 48, 49, and 50) surrounded by dense, long scales along posterior margin of abdominal segment VII; strongly chitinized with exception of small area mesoventral to abdominal segments VIII, IX, and X; sparsely chitinized area about one-fifth as broad as corresponding segments. Genital opening situated ventromesal to VIII, subcircular, diameter about three-tenths as broad as VIII, bordered with highly chitinized plates laterally. Highly chitinized plate subtriangular, angulate laterally, about two-thirds as long and one-half as broad as abdominal segment VIII (segment bearing chitinized plates), terminating in another chitinous plate, which is suboval from caudal aspect, emarginate ventrally, beset with long and short setae at margin and with short stout setae at surface, except at anal opening. Anal opening subfusiform, occupying about one-third total surface area of chitinous plate.

Pupa (*pl. 5, fig. 25, 26, and 27*). Length (based on one hundred specimens) 12 to 19 millimeters, average 14.5; width 2.8 to 4, average 3.34. Body subfusiform; rugose; sparsely beset with minute bristles and spines; anterior end rounded; tapering posteriorly from abdominal segment VI, forming a cone distally; general color in older pupae fuscous; variations due to differences in ages, as follows: immediately after pupating, head, thorax, and ventral part of abdomen whitish yellow, dorsal part yellowish pink; an hour later abdominal tergites pink and light pink posteriorly;

after the second hour, pinkish yellow ventrally and brown dorsally; six hours later, general color brown, which gradually changes to fusco-rufous until it finally becomes fuscous; cephalic and caudal extremities and thoracic nota darker than rest of body.

Head projecting slightly cephalad from base of antennae. Frons subrectangular, beset with two fine bristles anteriorly and two minute bristles basally near insertion of antennae. Vertex subrectangular with a median suture, about one-fourth width and one-fifth length of prothorax. Antennae clearly seen from lateral and ventral aspects, nearly subcoextensive apically with maxillae and fore wing pads, bounded by fore wing pads and mesothoracic legs, segments distinct especially when approaching emergence, insertion in head clearly seen from lateral aspect just dorsally from eyes, about one-third as broad as mesothoracic legs and about one-half as long as total length of body. Eyes situated caudoventrally with respect to base of antennae, subspherical, shiny, easily visible from lateral and ventral aspects, diameter about twice width of base of antenna; labial palpi small, situated between basal portion of maxillae. Maxillae attached to caudoventral part of head and extending to posterior margin of fore wings, tapering distally from base; basal portion about three times as wide as distal, about one-half as long as total length of body, subequal in length to antenna.

Thorax subcylindrical with a mesal carina; appendages applied closely against body ventrally; about one-fourth as long as total length of body; pro-,meso-, and metathoraces exposed dorsally, covered by cephalic and thoracic appendages ventrally; prothorax subcrescentic from dorsal aspect, beset with four fine bristles dorsally; fore leg fixed between maxillae and mesothoracic legs, extending nearly half way caudally between extremities of wings, tapering distally, about two-thirds as broad and three-fifths as long as middle leg; femora of fore legs lying between maxillae and tarsi of fore leg, subfusiform. Mesothorax beset with two pairs of bristles, margins anteriorly concave, posteriorly convex, about twice as long as abdominal segment I; fore wings extending to abdominal segment IV, about one-half as long as total length of body and of nearly the same breadth as abdominal segment VII; mesothoracic legs extending caudally to posterior margin of hind wings, situated between fore leg and maxillae anteriorly and between antennae, hind wings, and hind legs caudally; metathorax subrectangular from dorsal aspect, anterior margin concave, posterior margin forming caudolateral angles with dorsolateral margins of hind wings, about as long as abdominal segment II, beset with a pair of dorsal and a pair of lateral minute bristles anteriorly, hind wings extending posteriorly beyond caudal margins of fore wings and partly seen along dorsolateral margins basally; hind legs situated between distal ends of middle legs, extending caudally beyond distal ends of maxillae.

Abdomen rugose with transverse wrinkles dorsally; subcylindrical; tapering posteriorly, as noted above; about three-fourths as long as total

length of body; ten segmented; I, II, and III exposed dorsally and covered with head and thoracic appendages ventrally; I about one-fifteenth as long as total length of body and about as long as either II or III; IV about twice as broad as long, abut one and one-third times as long as III; V about one and one-fourth times as long as and nearly the same breath as IV; VI narrower than V and about the same length of IV; VII tapering distally, about five-sevenths as long as VI; VIII tapering posteriorly, about two-fifths as long as VII; IX tapering caudally, subequal length of VIII; X about as long and two-thirds as broad as IX. II to VIII, each with a pair of spiracles; spiracles ovate, very highly chitinized and slightly elevated; III to VIII, each with one to two pairs of spines dorsally, spines situated caudally with respect to dorsal bristles; V to VII movable at transverse conjunctivae, each segment with a pair of punctures which are situated anterior to spiracles; V and VI each bearing a pair of proleg scars (circular depressions) on sterna of each segment which are situated caudomesally with respect to ventral bristles; VIII with slitlike structures representing genital openings; male genital opening (pl. 6, fig. 32) situated ventromesally, posterior to spiracles; female genital opening (pl. 5, fig. 29) ventromesally, anterior to spiracles; IX bearing ventromesal anal slit, which is similar in position in both sexes; X narrow, horny, dark posteriorly, a lateral furrow on either side, distal and bearing cremaster (pl. 6, fig. 30 and 33).

Sixth instar larva (pl. 3, fig. 9 and 10). Length (based on eighty larvae) 17 to 29 millimeters, average 22.96; width 2.8 to 4.5 average 3.32. Head capsules, length (based on four specimens) 1.85 to 2.08, average 1.96; width 18.5 to 2, average 1.94. General color, light brownish yellow. Body elongately subfusiform. Head, fuscous; ocelli, basal parts of antennae, submentum, mentum, and clypeus white; mandibles dark brown; maxillae, labium, and distal segment of antenna reddish brown. Thorax and abdomen soft, light brownish yellow dorsally with a narrow mesal laterally diffused darker yellowish brown line extending from mesonotum to subcaudal abdominal tergite, bounded on either side by hazy scattered, diffused brownish yellow patches, thence laterally by a broad diffuse area extending almost to lateral conjunctivae; verrucae, spiracles, apical portion of legs, and crochets of prolegs markedly darker yellowish brown than rest of thorax and abdomen, subunicolorous; ventral parts of thorax and abdomen brownish white; segments distinct.

Head (pl. 3, fig. 11 and 12) about five-sevenths as long as broad; subequal length and width of prothorax. Epicranium sparsely beset with setae; subspherical; slightly compressed dorsoventrally; two-thirds as thick as wide; outline from cephalic aspect broadly oval; slightly wider than long. Vertex, deeply grooved. Frons subtriangular; anterior margin straight and slightly shorter than caudolateral margin; caudolateral margin incurved entally at about one-third from caudal end of frons; describing an angle of about 43 degrees. Adfrons about as wide anteriorly as distal segment of

antennae; posteriorly about one and one-third times width of antennae; tapering at both extremities into acute angles. Ocelli in groups of six on either side, arranged on genae in anteriorly directed semicircle, spherical, subequal in size to one another, diameter subequal to width of distal segment of antenna, opens lateroventrally. Antennae porrect, subequal in length to mandible, situated between mandibles and anterior margin of genae, three-segmented; I subconoidal, width about two-thirds length, about one-half total length of antennae; II subannular, length about two-thirds width, about one-third as long as I; III subcylindrical, about two-thirds as wide and three times as long as II, distal end bearing three short stout spines and a long stout bristles; bristles about as long as total length of antenna. Clypeus subrectangular; posterior margin subcoextensive with anterior margin of frons; length about one-sixth width. Mouth parts occupying about one-fourth length of head. Labrum subcrescentic from cephalic aspect, anterior margin emarginate mesally; about as long as and two thirds as wide as clypeus; aparsely beset with short stout setae. Mandible extending apically beyond anterior margin of labrum; about one-fourth as long as head; subtriangular; diameter at base about two-thirds length. Maxilla porrect; width at base about two-thirds basal diameter of mandible, subcylindrical, tapering distally; cardo subtriangular, about one-half as wide as long; stipes subrhomboidal, about one and one-third times as long and the same proportion in width as cardo, about one-half total length of maxilla, beset with two stout bristles; dististipes about one-fourth as long and one-third as wide as stipes; a stout bristle ventrodistally; palpifer subannular, about as long and three-fourths as broad as dististipes: a lateroventral bristle distally near base of galea; maxillary palpus two-segmented; I subconoidal, about as long as and one-half diameter of palpifer, II subellipsoidal, about two-thirds as long and nearly the same proportion in diameter as I, about as long as broad; galea about as long and one and one-third times as broad as segment I of maxillary palpus, distally two short stout and three larger subcylindrical spines, which are about one-half length and one-third width of segment II of maxillary palpus. Labium applied closely against ventral contour of head; mentum and submentum fused together forming a subrectangular plate which is concave at lateral margins, two stout bristles lateromesally midway between basal and distal margins of plate; basilabium subcrescentic, about as broad and two-thirds as long as mentum; spinneret elongately subangular, about as long as mentum, width at base subequal to that of segment II of maxillary palpus; labial palpus subcylindrical, about two-thirds as long and one-third as broad as spinneret, one long and one short bristle at distal end.

Thorax subcylindrical; slightly tapering anteriorly; about one-fourth as long as total length of body; sparsely beset with setae. Prothorax (pl. 3, fig. 13) about five-sevenths as long as broad; about five-sixths as long and five-sevenths as wide as mesothorax; prothoracic shield subcrescentic from

caudal aspect, caudal margin emarginate; anterior margin broadly angular anteroposteriorly. Mesothorax (pl. 3, fig. 14) about five-ninths as long as wide, about as long and about as broad as mesothorax. Metathorax (pl. 4, fig. 15) about as wide and about as long as abdominal segment I. Thoracic legs gradually decreasing in size posteroanteriorly; each leg about as long as prothorax; subconical, terminated by a claw; coxa subspherical, length about as long as breadth, bearing five bristles, trochanter subannular and about one-third as long as broad, as broad as femur; femur subcylindrical, as broad as long, about as long and one-half as wide as coxa, beset with two bristles posteriorly; tibia subcylindrical, about as long as and slightly narrower than femur, six bristles around distal margin; tarsus about two-thirds as long and the same proportion in width as tibia, four bristles near insertion of claw; claw stout, sharply pointed, arcuate ventrally.

Abdomen (pl. 4, fig. 16, 17, 18, 19, 20 and pl. 5, fig. 21, 22, 23, 24) subcylindrical; slightly tapering posteriorly; ten-segmented; abdominal segments I to VIII bearing each a pair of spiracles; spiracles oval and highly chitinized; III to VI, each with a pair of sensory pores; sensory pores (highly chitinized spots) situated caudally with respect to spiracles; II to IX with one to two strongly chitinized spots cephalad of *a* within the verruca; III, IV, V, VI and X, each with a pair of prolegs; prolegs on abdominal segments III to VI about one and one-third times as long as broad; triordinal, crochets arranged penelliptically, a dark spot at center of planta; proleg on X longer and larger than those on III to VI, inclusive, sparsely beset with bristles, crochets arranged anteriorly and occupy one-half margin of distal end. Abdominal segment I about as long and four-fifths as broad as II; II about one-half as long as broad, about five-sixths as long and nearly the same breadth as III; III about five-ninths as long as broad, about as long and nearly the same breadth as IV; IV about five-sixths as long and nearly the same breadth as V; V subequal in length and in width to VI; VI about as long as and slightly broader than VII; VII about one and one-half times as long and one-third as wide as VIII; VIII about two-thirds as long as broad, about twice as long as IX; IX about five-ninths as long as broad, subequal length and breadth of X; X bearing suranal plate; suranal plate angulate laterally; emarginate at anterior border.

Fifth instar larva (pl. 3, fig. 8). Length (based on nineteen larvae) 14 to 22 millimeters, average 18.1; width 2 to 3, average 2.5. Head capsules, length (based on two specimens) 1.33; width 1.39. Chaetotaxy, general color, and other superficial morphological characters similar to those of sixth instar, with exceptions noted below:

Head subcircular in outline at dorsal aspect; length about five-sevenths width; subequal length and breadth of prothorax.

Thorax subcylindrical; pro-, meso-, and metathoraces subequal in length and in breadth; length about five-eights width, about one and one-sixth times as long and as wide as abdominal segment I.

Abdomen subcylindrical; slightly tapering posteriorly; I about one-half as long as wide, subequal in width and five-sixths as long as II; II five-eighths as long as broad, about as long and as broad as either III, IV, V, VI or VII, which are of subequal dimensions; VII about four-sixths as wide and as long as VIII; VIII about twice as long and one and one-third times as broad as IX, length about five-eighths width; IX about five-twelfths as long as wide, subequal length and breath of X.

Fourth instar larva (pl. 3, fig. 7). Length (based on fifteen larvae) 11 to 17 millimeters; average 13.3; width 1.5 to 2.5, average 2. Head capsules, length (based on nine specimens) 1.1 to 1.33, average 1.22; width 1.1 to 1.3, average 1.23. Chaetotaxy, general color, and other external morphological characters similar to sixth instar, with exceptions noted below:

Head about five-sevenths as long as broad, about as long as prothorax.

Thorax with prothoracic shield subconcolorour with head; pro-, meso-, and metathoraces subequal in length and in width; length about five-eighths width, about as broad as and about one and one-fourth times as long as abdominal segment I.

Abdomen tapering posteriorly from abdominal segment VII; I about as long and five-sixths as wide as II, length about one-half width; II about one-fourth as long and as broad as III, length about five-sevenths width; III about five-ninths as long as broad, subequal in length and in width to either abdominal segments IV, V, VI, or VII, which are of subequal dimensions; VII about one and one-fifth times as wide as VIII; VIII about five-ninths as long as wide, about twice as long and one and one-fourth times as wide as IX; IX about five-fourteenths as long as wide, about five-sevenths as long and of the same width as X.

Third instar larva (pl. 3, fig. 6). Length (based on twenty-one larvae) 5 to 10 millimeters, average 7.83; width 0.8 to 1.5, average 1.1. Head capsules, length (based on seven specimens) 0.81 to 1.2, average 1.07; width 1.08 to 1.23, average 1.18. Chaetotaxy and other external morphological characters subequal to sixth instar, with exceptions noted below:

Head subcircular in outline at dorsal aspect; length about five-sixths width, about one and one-third times as long and nearly the same breadth as prothorax.

Thorax brownish white with dark brown prothoracic shield ; pro-, meso-, and metathoraces subequal length and width; length about five-ninths width, about one and one-half times as long and of nearly the same breadth as abdominal segment I.

Abdomen subconcolorous to thorax dorsally and creamy white ventrally; I about five-elevenths as long as broad, subequal length and width of II; II about five-sixths as long and of the same width as III; III about five-ninths as long as broad, about as long and as broad as either IV, V, VI, or VII, which are subequal in dimensions; VIII about five-sevenths

as long as broad, subequal in length to and seven-eighths as wide as VII; IX about one-third as long as broad, about two-fifths as long and nine-elevenths as wide as VIII; X about five-ninths as long as broad, subequal in width to and one and one-third times as long as IX.

Second instar larva (pl. 3, fig. 5). Length (based on twenty-four larvae) 3.5 to 7.1 millimeters, average 5.35; width 0.6 to 1, average 0.85. Head capsules, length (based on eleven specimens) 0.80 to 0.95, average 0.86; width 0.75 to 1, average 0.86. Chaetotaxy and other external morphological characters subequal to sixth instar, with exceptions noted below:

Head subcircular in outline at dorsal aspect, dark brown, subequal length and width of prothorax.

Thorax pale yellow with dark brown prothoracic shield; pro-, meso-, and metathoraces subequal in length and in breadth, about as long and as broad as abdominal segment I.

Abdomen pale yellow dorsally and creamy white ventrally; slightly tapering posteriorly from abdominal segment VII; crochets on prolegs of III to VI, inclusive, arranged penelliptically in two rows; I about as long and as broad as either II, III, IV, V, VI, or VII, which are of subequal dimensions; VIII about two-thirds as long as broad and the same proportion in length as VII; IX about two-thirds length and breadth of VIII; X about as long as broad as IX.

First instar larva (pl. 3, fig. 4). Length, newly hatched (based on fifteen larvae) 2 to 2.8 millimeters, average 2.32; width 0.2 to 0.4 average 0.3. Length immediately prior to molting (based on twenty-one larvae) 3 to 4.6, average 3.65; width 0.4 to 0.75, average 0.53. Head capsules, length (based on seven specimens) 0.70 to 0.84, average 0.76; width 0.70 to 0.84, average 0.77. Chaetotaxy and other external morphological characters subequal to those of sixth instar, with exceptions noted below:

Head (pl. 3, fig. 3) subcircular in outline at dorsal aspect, about as long as broad, subequal in length to prothorax and about two-thirds as wide.

Thorax pale yellow with dark brown prothoracic shield; microscopic setae *alpha, beta, delta, epsilon,* and *tau* and setae *theta* and *sigma,* which are present in older instars, absent; pro-, meso-, and metathoraces subequal in length and in width, each about as long and as broad as abdominal segment I.

Abdomen pale yellow dorsally and creamy white ventrally; microscopic setae β and IIIa, seta μ sensory pores, and chitinized spots cephalad of *a,* which are present in older instars, absent; verrucae not distinct; *pi* of abdominal segments I to VI, inclusive, represented by two setae; of VII by one seta; crochets at distal ends of prolegs on III to VI, inclusive, arranged penelliptically in one row; segments I, II, III, IV, V, and VI are of subequal dimensions; VII subequal in length to and about three-fourths width of VI; VIII about three-fourths length and width of VII; IX about two-thirds as broad and one-fourth as long as VIII; X subequal length and width of IX.

Eggs (pl. 3, fig. 1 and 2). Length (based on fifty specimens) 0.72 to 1.15 millimeters, average 0.87; width 0.61 to 0.77, average 0.67; thickness 0.15 to 0.3, average 0.22. Flat; outline oval to subcircular, surface shiny. Newly laid eggs pale yellow to yellowish white, gradually changing to yellowish brown and finally to black when about to hatch. Usually in imbricated masses from six to one-hundred and thirty eggs; average, thirty-six eggs (table 3).

Life history and habits

The life history records in the present report are based on cultures carried on under insectary conditions from October, 1924, to November, 1925—a total of a little over twelve consecutive months. The data are given in tables 1, 4, 5, 6, 7, 8, and 9. The results are discussed separately under their respective headings.

Number of generations during the year. The corn borer was found to be in season throughout the year. Material could be gathered in any stage in practically any month, varying, of course, in abundance, as noted later on. The work on the determination of the number of generations was begun about the end of October, 1924. Unfortunately the cultures which closed on August 26, 1925, produced only sterile eggs, a condition which naturally broke the hitherto uninterrupted chain of generations. The stock was replenished with fresh material, which began the cycle at as close a date as possible, August 21, 1926. The work was continued to November 8, 1926. Virtually, there was no break in the line, except for change of stock.

The results are given in table 1, wherein it will be noted that during a period of one year *Pyrausta nubilalis* may pass, under laboratory conditions, through approximately nine generations. The same condition probably obtains in the field, since this species has never been found at any time to pass through any prolonged dormant stage. By way of comparison the following list of the number of annual generations of the corn borer in other countries is given:

Nearctic Region

Countries	*Authorities*	*Annual number of generations of the corn borer, Pyrausta nubilalis Hübn.*
United States:		
New York	Felt (1923)	Two generations (normally)
	Barber (1925c)	One generation
New England	Pettit (1925b)	Two generations
	Drake (1926)	Two generations
	Barber (1925c)	Two generations
	Coffrey and Vinal (1919)	Two generations
	Felt (1923)	Two generations
Michigan	Pettit (1925b)	One generation
Illinois	Flint and Malloch (1920)	Two generations
Ohio	Drake (1926)	One generation
Canada	Pettit (1925b)	One generation
Ontario	Drake (1926)	One generation

	Palaearctic Region	
Russia:		
Caucasus	Uvarov (1917)	Two generations
Don (district)	Dobrodeiv (1921)	Two generations
Veronezh	Dobrodeiv (1921)	One generation
Italy	Caffrey and Worthley (1927)	Two generations
Hungary	Worthley	One generation
Belgium	Worthley	One generation
France:		
Toulouse	Rives (1919)	Two generations
	Oriental Region	
Philippine Islands:		
Los Baños	Present report	Nine generations

Length of life cycle. Table 1 shows that the life cycle differs in duration with the time of the year. The minimum was found to be 32 days, in May and June, 1925; the maximum 53 days, in November and December, 1924; the lowest average, 35.6 days, in June and the first half of July, 1925; and the highest, 50.5 days, in September to November, 1925. The shortest life cycle occurred during the latter part, covering more than half, of the dry season, when the temperature rose to a maximum of 33°C. in May, 1925. The longest life cycle occurred during the rainy season, especially at the time when the monsoons brought from northern latitudes low temperatures. A tentative conclusion is therefore drawn that high temperatures in combination with other climatic factors prevailing at the time under consideration rendered the life cycle, under laboratory conditions, short, and conversely, low temperatures, in combination with high average precipitation, lengthened it. This condition may be interpreted as being partly caused by high temperature accelerating chemical reactions in the body of the developing insect and low temperature retarding them. The insect spends the larval and pupal stages inside the plant so that it would be less likely to suffer from direct effect of drastic climatic changes than if it were an exophagous species. The short duration of life cycle therefore can not be taken as an index of favorable conditions for growth of *Pyrausta*.

Emergence and copulation. The newly emerged moth has its wings crumpled. It takes five to ten minutes for the appendages to straighten.

In captivity, the adults spend most of the time resting on the underside of the cloth cover and on the walls of the battery jar. They occasionally move to the wet pellet of cotton to drink. Under natural conditions in the field, they hide under the leaves of the corn plant and in most cases under the leaves of weeds in the corn field and vicinity during the day time. They begin to fly at dusk.

The male and the female copulate within a day after emergence. Mating usually occurs at from three to five o'clock in the morning. The process lasts usually for from fifteen to twenty minutes. During copulation, the female and the male face in opposite directions and join the caudal ends of

the abdomen. The body of the male is usually flexed downward. The outer margins of the wings of the female overlap those of the male. They are both at rest when in copula.

Observation on several couples both during the day and during the night seemed to indicate that copulation takes place only once during the life of the female. For confirmation controlled experiments were performed. In one set the males were kept with the females and left until one died and in the other set the males were removed soon after the first batch of fertile eggs were laid. The results are given in table 2. In both cases the eggs were invariably fertile, since they hatched in time. Moreover, the subsequent removal of the male did not seem to interfere with the total number of eggs deposited by the female.

Time, place, and manner of oviposition. The female lays eggs in the evening, apparently between seven and twelve o'clock. In cases the writer had a chance to observe, the process first occurred in from one to three days after emergence (table 4) and about nineteen hours after copulation. While ovipositing, the female was at rest with the caudal end of the abdomen bent downward and swaying alternately to right and left as she advanced forward by degrees. The eggs were found in a few cases to be deposited at the rate of about ten per minute. They were laid either singly or in masses of two to two hundred on the walls of the containing jar or on the underside of the cloth cover. Under natural conditions, the females deposited eggs in imbricated fashion (pl. 3, fig. 2) in masses of from six to one hundred thirty with an average of 36.28 (see table 3) on the nether (pl. 1, *right*) surfaces of corn leaves. The fifth to tenth leaves seemed to be preferred. In rare cases eggs were laid on the upper surface of the leaf.

The insect does not seem to have seasons for oviposition. This statement is borne out by the fact that infestation usually begins at the tasseling stage and continues up to the glazing stage of the corn plant in any month of the year (table 10). In general, however, there are only two corn growing seasons in most parts of the Islands; in regions represented by Los Baños and vicinity, from May to August in the rainy season, and from October to December in the dry season.

Longevity of adults and period of fecundity. Under laboratory conditions, during the period from the end of October to about the end of December, 1924, and from the middle of March to the end of April, 1925, the adults were found to remain alive in captivity as follows (see tables 5 and 6):

Males 2 to 16 days; average 8.34

Females 2 to 19 days; average 8.5

It will be noted that there was but little difference under laboratory conditions between longevity in the adult stage of the male and of the female. The adult females were slightly longer lived. There was no evident difference between length of adult life in the dry season and in the

rainy. Purposely no food was given, although perhaps the adults were able to sip some of the sweet juice that exuded from the cut ends of corn stalks in the jar. Plenty of water was supplied in wet pellets of cotton.

In captivity, the female was found to lay eggs through a period of from 1 to 12 days; average 5.43 days (table 7). She either died while still fecund or survived her egg-laying period by a miximum of 5 days; average 1.94 days (table 5).

Daily and total oviposition record of individual females. The rate of daily egg-laying was irregular as shown in table 9. In a number of cases, days of active oviposition were followed by one or more days in which no eggs were laid. After this short rest, the process was resumed with renewed vigor. The number laid daily varied from 0 to 365, with an average of 77.6. The total number of eggs laid during the life of the female varied from 115 to 1193, with an average of 465.2.

Incubation period. The incubation period varied from 4 to 5 days, with an average of 4.33 (table 1). It was found that eggs in a given mass hatched at the same time. On account of the small number of egg masses observed, no very definite conclusions can be made as to effect of climatic factors on incubation.

Duration of larval stage and stadia and habits of larvae. On hatching, the larva cuts an irregular opening through the chorion and crawls out. The newly hatched caterpillar feeds on the epidermis of the tender leaf blades near the place of hatching. Subsequently, however, it migrates to some other parts of the plant and eats its way into the stalk, where a leaf sheath covers it. Some individuals gain entrance into the flower buds in the tassel, while others may be blown by the wind while crawling and in this way succeed in reaching other corn plants. The most common point of attack is at or near the nodes of the stalk, where the plant tissue is tender. It seems probable that the larvae do not remain in one tunnel, but crawl out from time to time and bore into fresh parts of the same plant, or as is more frequently the case, of another. This supposition is based on the fact that although the earlier instars were found in large numbers in tunnels within one plant, yet in no instance were the older larvae particularly numerous. Moreover, in the field full grown caterpillars were found to have bored fresh tunnels into corn stalks and ears (pl. 1. (*left*) and pl. 2).

The presence of the corn borer may be detected by the trash collecting at the opening of the tunnels. Another easily noticeable sign of infestation is broken tassels with accumulated trash at the cut ends. Prevalence of attacked ears also furnish tell-tale clues. The tunnels are usually directed upward. In most cases only one larva inhabits a tunnel.

Severely attacked plants may harbor as may as sixteen larvae of different ages, and even pupae, in the stalk. A maximum of three larvae was found infesting each internode.

Molting is carried on inside the tunnels. In the first and second instars, the act does not seem to interfere with feeding, save in the actual process of shedding the exuviae. In the subsequent instar, however, the larvae may cease feeding for as long as twelve hours preparatory to ecdysis. They then become somnolent and inactive, lying on one side, with the body conspicuously flexed ventrally. The skin then splits dorsomesally at the thorax and by continuous bending and wriggling the caterpillar soon extricates itself from the old skin. The freshly molted larva of the later instars needs about six hours to harden the body parts sufficiently to feed.

Preliminary to pupation, the full-grown caterpillar moves to the lower end of the tunnel, near the opening. The burrow behind is then plugged with compacted trash and loose silken strands spun across the opening. Sometimes the larva encloses itself in a thin cocoon, but very often this structure is dispensed with. The final position on pupating is with the head directed downward.

Occasionally the larva goes clear out of the tunnel and pupates among the ear husks. In this position, it invariably incloses itself in a cocoon.

The larval stage varies from 18 to 41 days, with an average of 28.89 (table 10). The smallest average in the nine generations studied, 21 days, was between June 4 and July 11, 1925, and the largest 33.95, between October 29 and December 18, 1924.

There are six larval stadia, lasting as follows:

First stadium 2 to 6 days; average 3.55
Second stadium 2 to 5 days; average 3.56
Third stadium 3 to 6 days; average 3.78
Fourth stadium 3 to 6 days; average 3.87
Fifth stadium 3 to 7 days; average 4.64
Sixth stadium 4 to 21 days; average 11.48

It will be seen from the foregoing averages that there is a very slight progressive increase in duration from the first to the fourth stadium; the fifth stadium is longer than the fourth by a little less than a day; and the sixth is more than double the fifth.

The pupal stage ranges from 5 to 12 days, with an average of 8.3.

Seasonal occurrence and abundance. The corn borer occurred throughout the years 1925 and 1926 in the College of Agriculture Experiment Station, Los Baños, and on the neighboring farms. In the vicinity of the College of Agriculture, cropping of corn was continuous throughout these two years except from October to December, 1925, when the plant was very scarce. During this interval of time, the corn borer was found feeding on sorghum. The area planted to corn varied in size from season to season and when the planting was small the intensity of infestation was naturally great. The relation of the degree of infestation to the growth stages of corn is given in table 10. In this table, it will be seen that corn becomes susceptible to corn borer infestation from tasseling

to glazing. This was almost invariably true, the only exception being an isolated case on June 18, 1925, of a corn field belonging to the Animal Husbandry Department which was infested before the plants tasselled. The pest was especially abundant from May to September in both 1925 and 1926 and several corn fields showed from 50 to 98 per cent infestation.

Susceptibility of different corn varieties. There are two varieties of corn grown in the College Farm and vicinity. The Native Yellow Flint was extensively planted at the College of Agriculture and on neighboring farms. Small areas in the Experiment Station ground were planted to sweet corn. These two varieties were found to be equally susceptible to the attack of the pest, but the vigorous healthy plants with large stalks of either variety were relatively more resistant to the injury of the corn borer. Very likely no corn variety is immune, for as reported by Drake (1926) in the United States, all varieties are susceptible to attack.

Alternative hosts. Sorghum was found attacked by the corn borer from October to December in 1925 when little corn was grown in Los Baños. Sorghum was grown continuously in all the seasons of 1925 and 1926, but it was free from corn borer infestation when corn was grown in large quantities. This fact indicates that corn is preferred to sorghum. Woodworth (1921) reports that corn, sorghum, millet, and *Panicum* spp. are the hosts of corn borer in the Philippines. Exhaustive search by the writer has failed so far to reveal any indication of attack by corn borer on our common species of *Panicum*.

Drake (1926) states that over two hundred species of plants are infested in the United States; but some of these hosts serve only to a limited extent as breeding plants. The others form temporary food or shelter plants for the winter. In Europe and Asia, the favorable breeding plants are reported to be chiefly hemp, hops, broom corn, millet, and certain wild grasses where there is no maize, but after this plant is introduced, it becomes the preferred host. Pettit (1925b) notes that corn is the first choice, then sorghum and other relatives.

During the course of the present work, no plants, either wild or cultivated, other than corn and sorghum were found attacked by the corn borer at any time.

Natural enemies

The following natural enemies were collected during the course of the present work. Many of the species have not yet been determined and are here reported by accession numbers. They are being sent to various specialists, who, it is hoped, will report on them in the near future. For a tabulated list, see table 11.

a. Enemies of larvae (table 11)

(1) Parasites: Acc. Nos. Ec 187 (*Chelonus communis* Baker (MS), Braconidae), Ec 186, Ec 195, Ec 197, Ec 198, and Ec 196 (*Xanthopimpla stemmator*)[4], Ichneumonidae).

[4] Determined by R. A. Cushman

(2) Predators: Acc. Nos. Ec 190 (*Phemius tibialis* Westwood, Harpactoridae), Ec 191 (*Sphodronyttus erythropterus* Burm., Harpactoridae), Ec 192 (*Proreus simulans* Stal., Chelisochidae), Ec 194 (*Carpophilus fovelcollis* Murr., Histeridae).

b. Enemies of pupae (table 11)

(1) Parasites: Acc. Nos. Ec 188 (*Chalcis euploeae* Hope[5], Chalcididae), Ec 189, and Ec. 361.

(2) Predators: Acc. Nos. Ec 191 (*Sphodronyttus erythropterus* Burm., Harpactoridae), Ec 193, and Ec 194 (*Carpophilus fovelcollis* Murr., Histeridae).

In America and in Europe, *Pyrausta nubilalis* has many known parasites, owing to more extensive work done on this pest in those continents. A list is given below:

Locality	*Authorities*	*Parasites*	*Parasites of*	*Source*
United States:				
New England	Barber (1925a)	*Trichogramma minutum* Riley	Eggs	Autochthonous
Massachusetts	Caffrey and Vinal (1919)	*Masicera myoidea* Desv.	Larvae	"
		Phorocera erecta Coq.	Larvae	"
		Exorista pyste Walk.	Larvae	"
		E. nigripalpis Towns.	Larvae	"
		Amblyteles brevicinctor Say	Pupae	"
		Epiurus pterophori Ashm.	Pupae	"
United States	Caffrey (1925)	*Angitia punctoria* Roman		Imported from Europe
		Exeristes roborator Fabr.		"
		Microgaster tibialis Nees.		"
		Phaeogenes planifrons Wesm.		"
		Eulimneria crassifemur Thom.		"
		Zenillia roseanae B. and B.		"
		Habrobracon brevicornis Wesm.		"
France	Vuillet (1919)	*Lydella stabulans* Mq.		Autochthonous
		Paraphorocera senilis Rond.		"
France	Poutiers (1922)	*Eulimneria crassifemur* Thom.		"
		Habrobracon brevicornis Wesm.		"
		Masicera senilis Rond.		"
		Rhogas testaceus L. A.	Eggs	"
		Trichogramma semblidis Auriv.	Eggs	"
		Zenillia roseanae B. and B.		"
Russia	Dobrodeiv (1920)	*Ceromasia interrupta*		"
Italy	Caffrey and Worthley (1927)	*Dexodes nigripes* Fall.	Larvae	"
		Eulophus sp.	Larvae	"

SUMMARY AND CONCLUSIONS

1. The corn borer, *Pyrausta nubilalis* Hübn. (Pyralidae, Pyraustinae, Lepidoptera), is one of the worst pests of corn in the Philippines.

2. This species is known under fourteen synonyms (Caffrey and Worthley, 1927) as follows: *Pyrausta nubilalis* Hübn., *Pyralis nubilalis* Hübn., *Pyralis silacealis* Hübner, *Pyralis glabralis* Haworth, *Botys sila-*

[5] Determined by C. F. Baker

cealis Freyer, *Botys lupulinalis* Guenee, *Botys zealis* Guenee, *Botys nubilalis* Lederer, *Botys lupulina* Heinemann, *Hapalia kasmirica* Moore, *Hapalia lupulina* Butler, *Pyrausta nubilalis* Meyrick, *Pyrausta polygoni* Dyar, *Pyrausta vastatrix* Schultze.

3. This insect is practically cosmopolitan, having been reported from all the zoögeographical regions, except the Australian and the Ethiopian. It is a native of the Old World, and is a recent immigrant in the New, where it was first introduced into the United States and Canada in 1909 and 1910 (Caffrey and Worthley, 1920).

4. Very little is known concerning the life history of the corn borer in the Philippine Islands. Considerable work on this pest has been done in Canada, United States, and Europe.

5. *Pyrausta nubilalis* occurs in all seasons in the College of Agriculture Experiment Station and vicinity. It usually infests corn at the stage from tasseling to glazing in the growth of the plant. It was found feeding on sorghum from October to December, 1925, when the corn plant was very scarce.

6. Indications of an infested corn field are broken tassels, presence of trash which collects at the openings of tunnels, and characteristic appearance of attacked ears.

7. Infestation of the corn crop on the College Campus and vicinity from October 4, 1924, to December 26, 1926, varied from 2 to 90 per cent, with an average of 50.5 per cent. The infestation of the corn fields by this insect from May to September in both 1925 and 1926 varied from 50 to 98 per cent. The greater intensity of infestation usually occurred during the time when the area planted to corn was small.

8. The two varieties of corn (Native Yellow Flint and Sweet Corn) planted at the College of Agriculture and on neighboring farms were found to be equally susceptible to the attack of this pest.

9. During the course of the present work, only corn and sorghum were found attacked by the corn borer. Sorghum was free from corn borer infestation when corn was grown in large quantities. This fact indicates that corn is preferred to sorghum as host.

10. All the stages (eggs, larvae, pupae, and adults) of the corn borer are oftentimes present concurrently in heavily infested corn fields.

11. Under natural conditions, the adults hide under the leaves of the corn plants and in the grass during the day. They begin to fly at dusk.

12. Under laboratory conditions, mating usually occurred at from three to five o'clock in the morning. The female laid eggs in the evening, usually about nineteen hours after copulation.

13. The female was found to lay eggs in masses of from 6 to 130 eggs; average 36.28 eggs, on the underside of the fifth to the tenth leaves

of corn. In the laboratory, the eggs were deposited on the walls and covers of the containing jars in masses of from 1 to 200 eggs.

14. The full grown larvae pupate in the tunnel just behind the opening, and sometimes among the ear husks.

15. Larvae at the earlier stage feed on the epidermis of the corn leaves and on the tassels and subsequently bore tunnels in the midribs and in the tender portion of the stalks. As they grow older, they migrate to and bore tunnels in the stalks and ears of the same or of other corn plants in the field. The tunnels extend to the lower portion of the stalks to about five centimeters above the surface of the ground.

16. Each tunnel was as a rule occupied by a single larva. As many as sixteen larvae of different ages were found in the stalk of a severely attacked corn plant. A maximum of three larvae were found infesting each internode.

17. There are six larval instars. Molting occurred within the tunnel.

18. Life history of the corn borer:

a. Incubation period, from 4 to 5 days; average, 4.33 days.

b. Larval stage, 18 to 41 days; average 28.89 days.

First stadium, 2 to 6 days; average 3.35 days.

Second stadium, 2 to 5 days; average 3.56 days.

Third stadium, 3 to 6 days; average, 3.78 days.

Fourth stadium, 3 to 6 days; average, 3.87 days.

Fifth stadium, 3 to 6 days; average, 4.64 days.

Sixth stadium, 4 to 21 days; average, 11.48 days.

c. Pupal stage, 5 to 12 days; average, 8.3 days.

d. Egg to emergence of adult 29 to 56 days; average, 41.47 days.

e. Life cycle 32 to 53 days, average, 43.69 days. The minimum life cycle occurred during the latter part, covering more than half, of the dry season, when the temperature rose to a maximum of 33°C.; and the maximum life cycle was during the rainy season when the temperature was low, in combination with high average precipitation.

19. This pest went through at least nine generations a year in the Philippine Islands. In the United States, Canada, Russia, Italy, Hungary, Belgium, and France, the insect has only one to two generations a year.

20. Longevity of adults: Male 2 to 16 days, average, 8.34 days; female 2 to 19 days, average, 8.5 days.

21. Copulation occurred within a day after emergence of the adults. The process took place once during the life of the female.

22. The time elapsing from the emergence of the female to first oviposition was from 1 to 3 days; with an average of 1.5 days.

23. The period of fecundity was from 1 to 12 days; average, 5.43 days.

24. The female survived its period of fecundity by from 0 to 5 days; average, 1.94 days.

25. The number of eggs laid daily by each female during the entire egg-laying period varied from 0 to 365 eggs, with an average of 77.6.

26. The total number of eggs laid by each female during the entire egg-laying period varied from 115 to 1,193, with an average of 465.2 eggs.

27. The natural enemies of the corn borer observed during the course of the present work in the College of Agriculture, Los Baños and vicinity: nine species of Hymenopterous parasites, including *Chelonus communis* Baker (MS), *Xanthopimpla stemmator*, and *Chalcis euploeae* Hope; two species of Hemipterous predators, *Phemius tibialis* Westwood and *Sphodronyttus erythropterus* Burm; one species of Coleopterous predator, *Carpophilus fovelcollis* Murr., one Dermapterous predator, *Proreus simulans* Stal.; and one Hymenopterous predator.

RECOMMENDATIONS

The following control suggestions are deduced from results reported in the present paper. Valuable pointers on control were also obtained from Caffrey (1922), Caffrey and Worthley (1927), Drake (1926), Huber and Neiswander (1924, 1927), and Pettit (1925).

1. Maintenance of healthy plants. Vigorous, healthy plants with large stalks suffer less than weak ones from injury from the attack of this insect.

2. Crop rotation and regulation of time of planting. Corn and other host plants of *Pyrausta* should be planted at approximately the same time in a given locality. The aim is to starve the pest by preventing it from getting access to suitable food at certain periods of the year.

3. Corn, sorghum, millet, and *Panicum* spp. are the known hosts of *Pyrausta* in the Philippines. *Panicum* is represented by several species of wild grasses; these should be eliminated from the field and vicinity so far as possible by thorough cultivation.

4. Infested corn plants should be cut close to the ground and fed to animals. That which is not eaten in the stables should be burned or buried so as to destroy all the larvae and pupae which may be present therein.

5. The stubble left on the ground should be plowed under as soon as practicable, even in fields which may not show signs of infestation.

6. These measures recommended are for the purpose of eliminating so far as practicable the possible sources of infestation, so as to protect subsequent crops. There must be wide-spread co-operation among all the farmers in a given locality. Combined efforts of a large community in this direction can easily be offset by a careless or indifferent corn planter in the neighborhood.

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ILLUSTRATIONS

(Magnifications indicated refer to size of original figures)

PLATE 1

Left. Corn ear partly exposed to show work of corn borer larvae.
Right. Egg mass *in situ* on nether surface of corn leaf.

PLATE 2

Portion of corn stem and ears showing work of corn borer larvae.

PLATE 3

Fig. 1. Egg, ×123
2. Egg mass. ×20.5
3. Head, first instar, ×123
4. First instar, lateral aspect, ×7.5
5. Second instar, lateral aspect, ×7.5
6. Third instar, lateral aspect, ×7.5

7. Fourth instar, lateral aspect, ×7.5
8. Fifth instar, lateral aspect, ×7.5
9. Sixth instar, lateral aspect, ×7.5
10. Sixth instar, dorsal aspect, ×7.5
11. Head, sixth instar, lateral aspect, ×40
12. Head, sixth instar, cephalic aspect, ×40
13. Prothorax, sixth instar, lateral aspect, ×40
14. Mesothorax, sixth instar, lateral aspect, ×40

PLATE 4

15. Metathorax, sixth instar, lateral aspect, ×40
16. Abdominal segment I, sixth instar, lateral aspect, ×40
17. Abdominal segment II, sixth instar, lateral aspect, ×40
18. Abdominal segment III, sixth instar, lateral aspect, ×40
19. Abdominal segment IV, sixth instar, lateral aspect, ×40
20. Abdominal segment V, sixth instar, lateral aspect, ×40

PLATE 5

21. Abdominal segment VI, sixth instar, lateral aspect, ×40
22. Abdominal segment VII, sixth instar, lateral aspect, ×40
23. Abdominal segment VIII, sixth instar, lateral aspect, ×40
24. Abdominal segment IX and X, sixth instar, lateral aspect, ×40
25. Pupa, lateral aspect, ×7.5
26. Pupa, ventral aspect, ×7.5
27. Pupa, dorsal aspect, ×7.5
28. Abdominal segments VII to X of female pupa, lateral aspect, ×40
29. Abdominal segments VII to X of female pupa, ventral aspect, ×40

PLATE 6

30. Abdominal segment X of female pupa, showing cremaster, lateral aspect, ×80
31. Abdominal segments VII to X of male pupa, lateral aspect, ×40
32. Abdominal segments VII to X of male pupa, ventral aspect, ×40
33. Abdominal segment X of male pupa, showing cremaster, lateral aspect ×80
34. Adult male, dorsal aspect, ×8
35. Adult female, dorsal aspect, ×8
36. Female, wings expanded, dorsal aspect, ×8
37. Head of adult male, scales and antennae partly removed, cephalic aspects, ×28

PLATE 7

38. Antenna of adult male, lateral aspect, ×28
39. Fore wing of adult male, ×16
40. Hind wing of adult male, ×16
41. Fore leg of adult male, ×14
42. Middle leg of adult male, ×14
43. Hind leg of adult male, ×14
44. Male genitalia, ventral aspect (harpes partly spread out), ×44

PLATE 8

45. Male genitalia, dorsal aspect (harpes partly spread out), ×44
46. Penis *in situ* within aedoeagus, ×160
47. Penis, ×160
48. Abdominal segments VII to X of female, showing ovipositor, ventral aspect, ×80
49. Ovipositor, ventral aspect, ×40
50. Ovipositor, lateral aspect, ×40

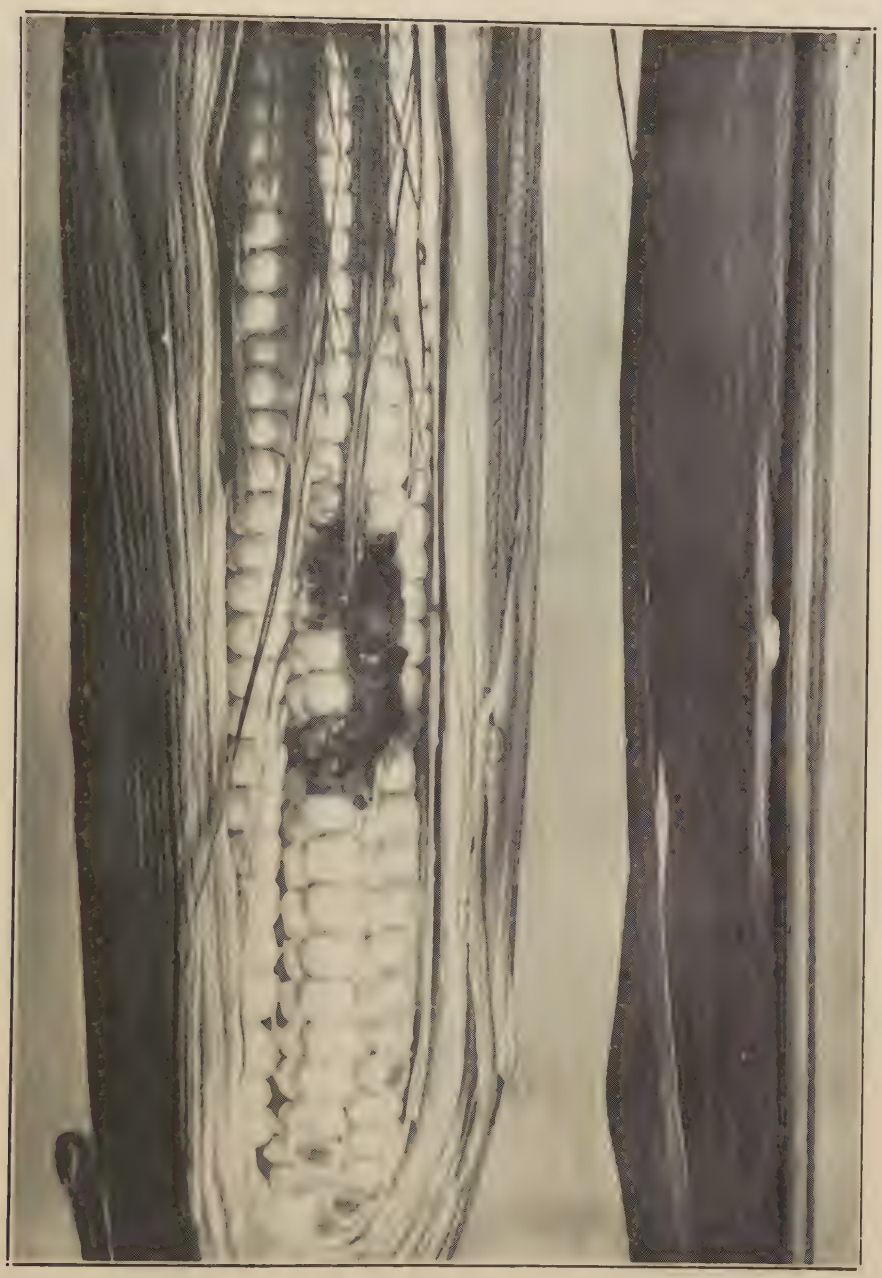
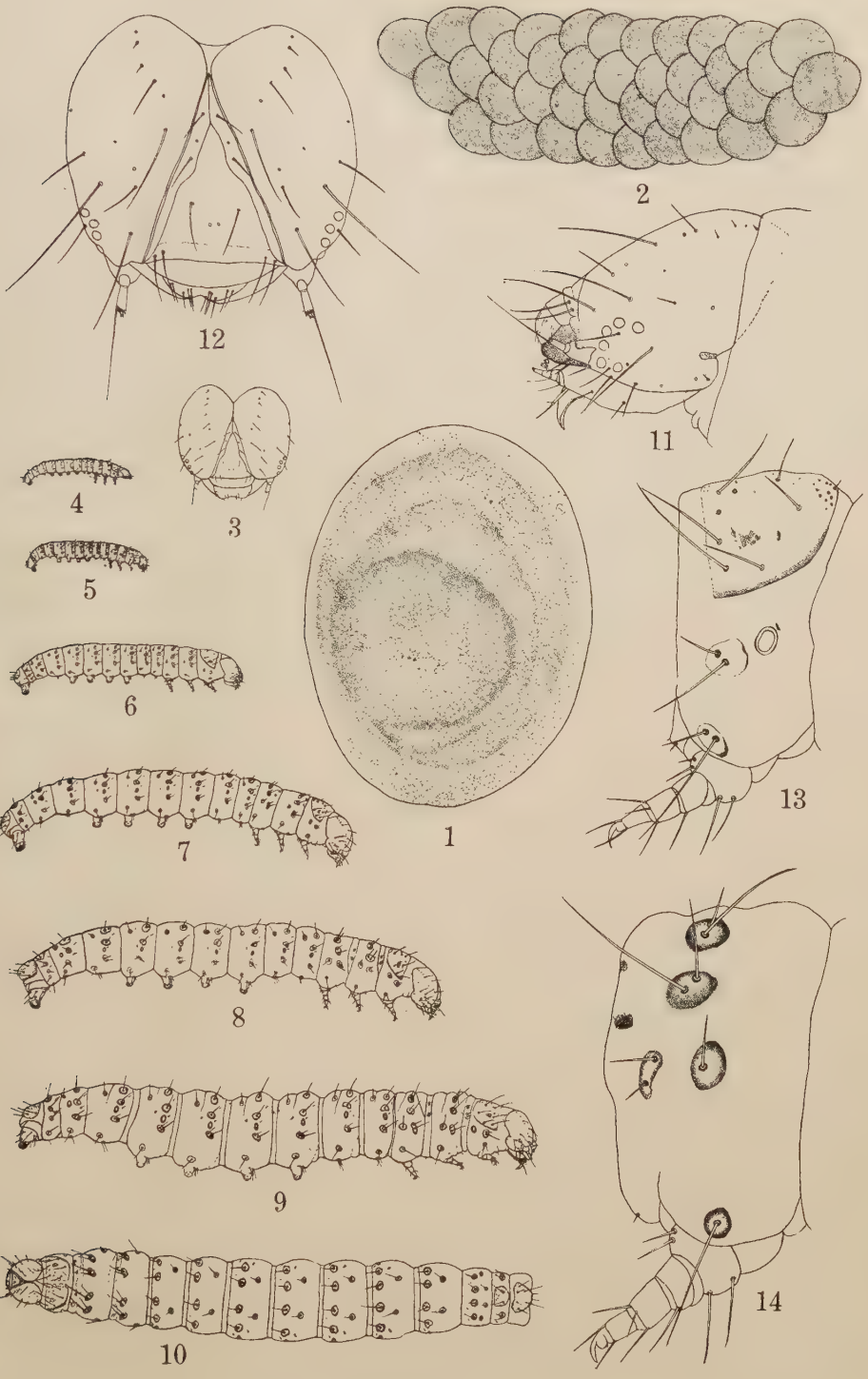


PLATE I

PLATE II



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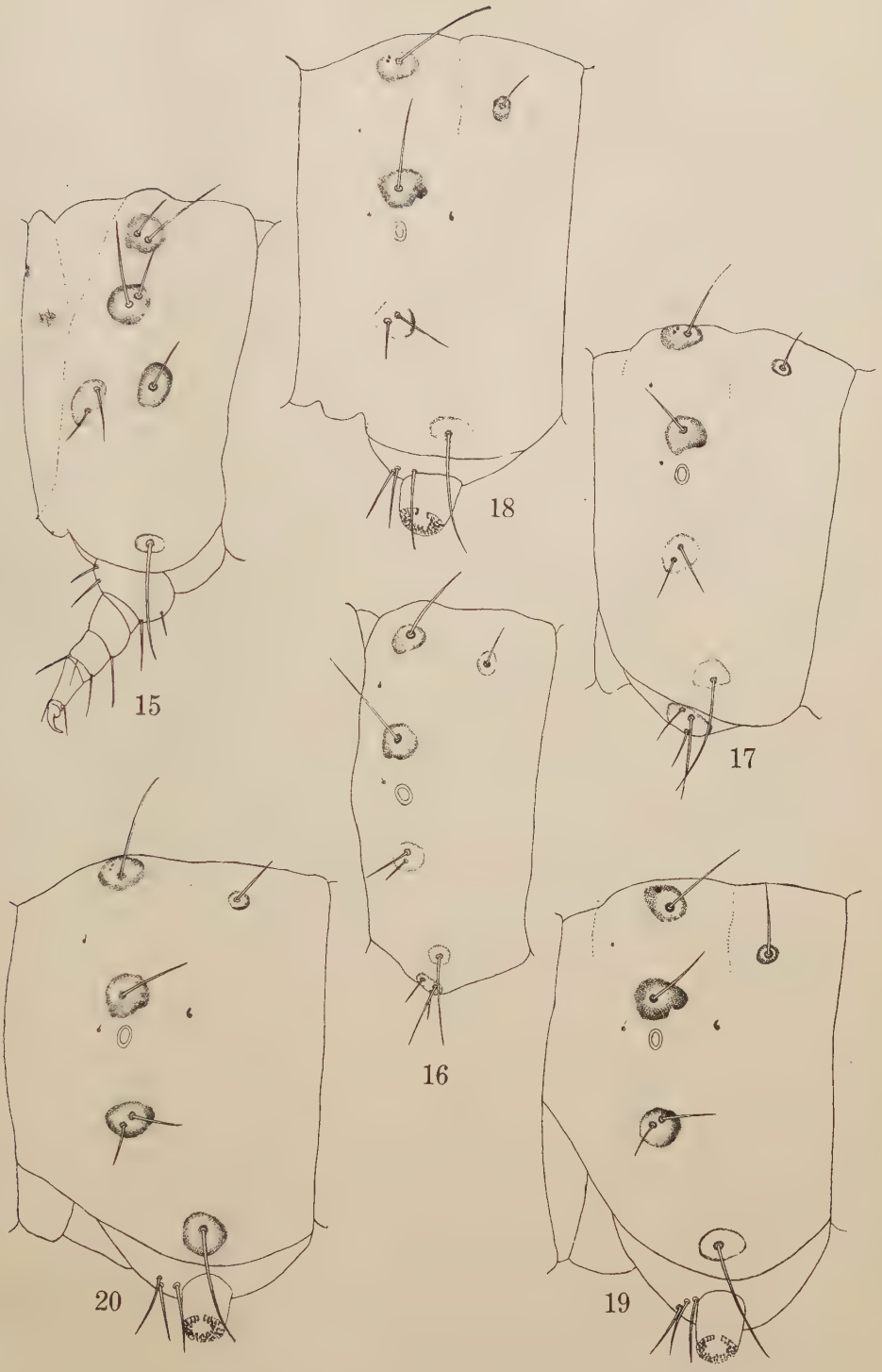

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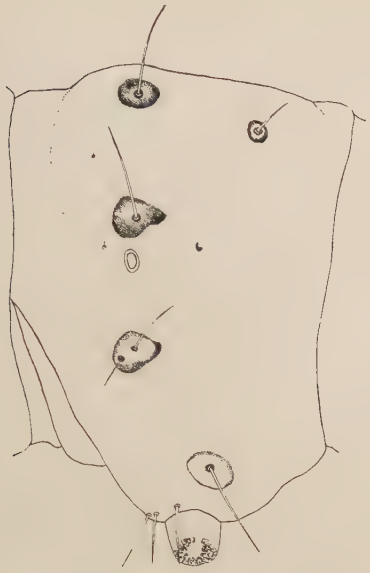

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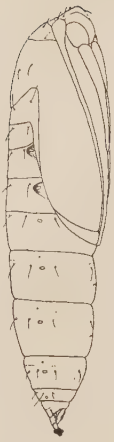

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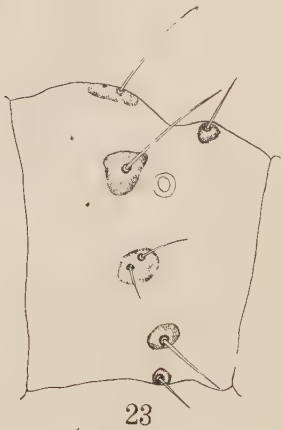

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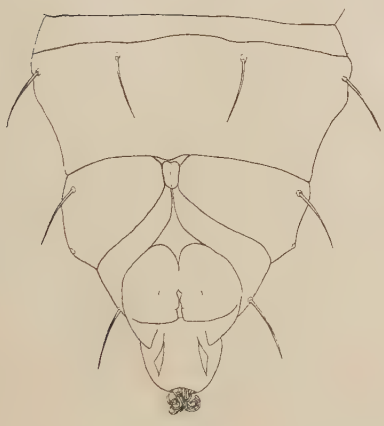

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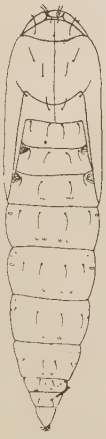

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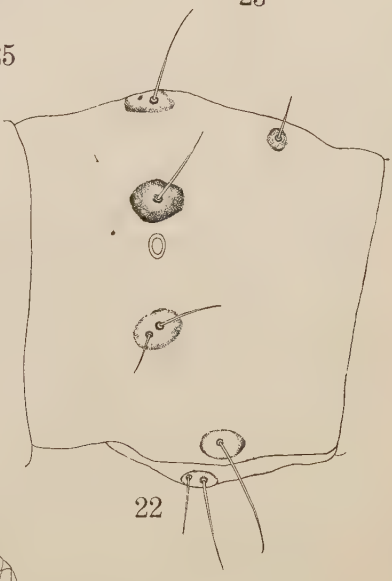

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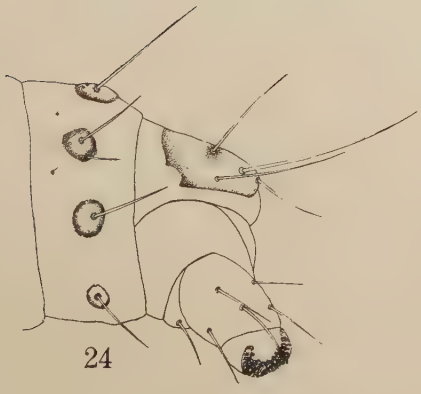

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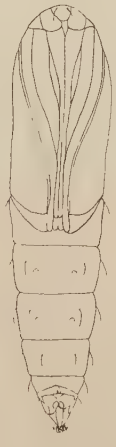

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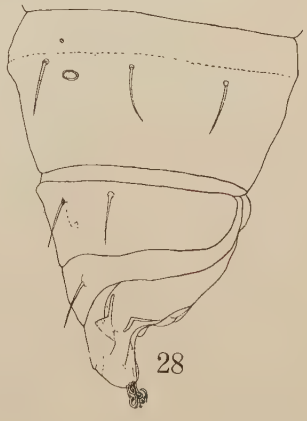

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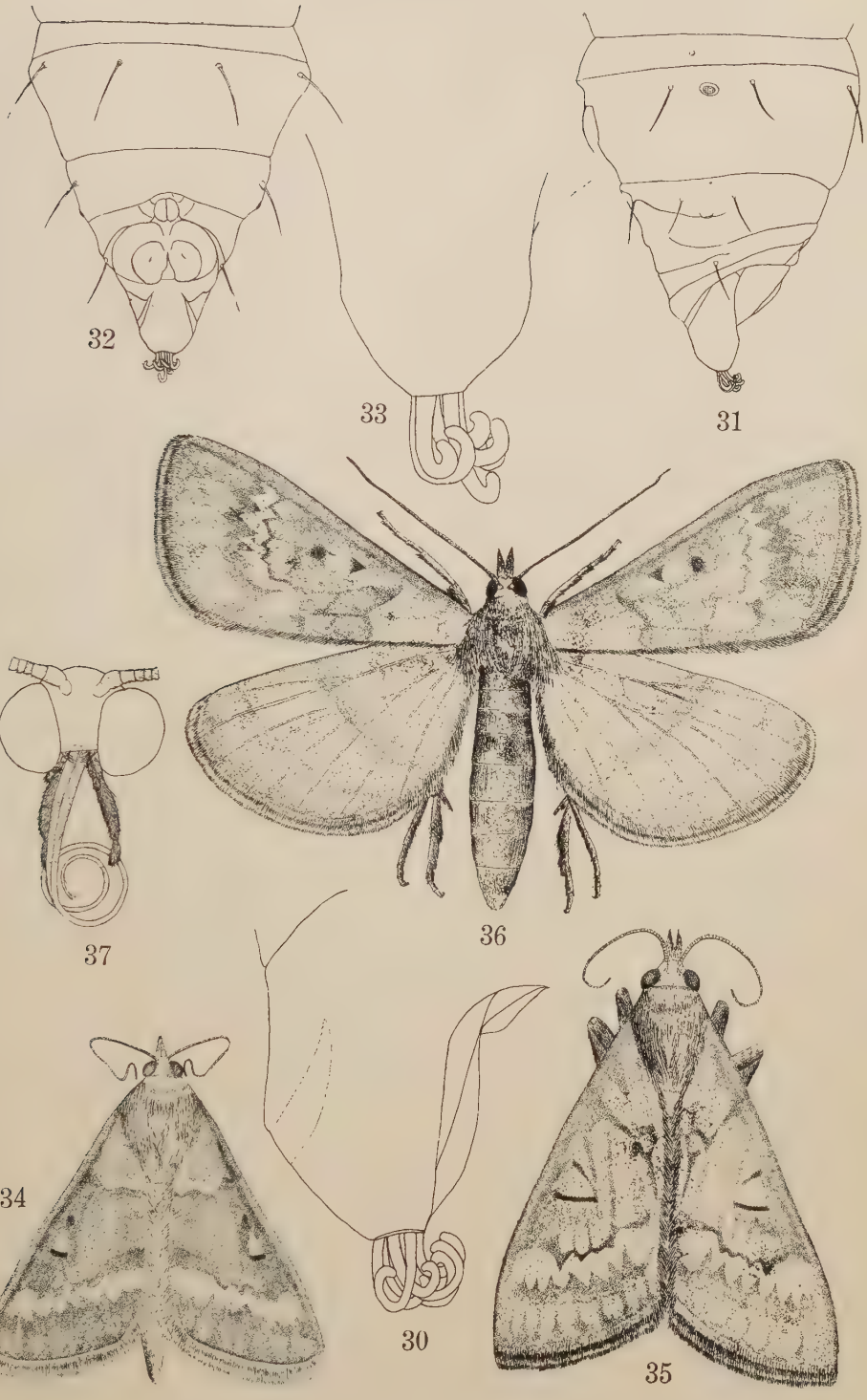

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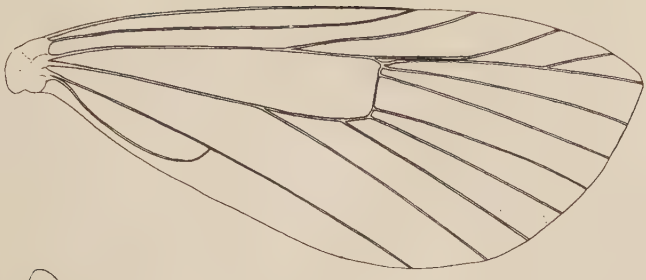

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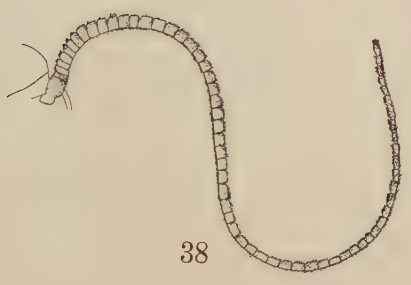

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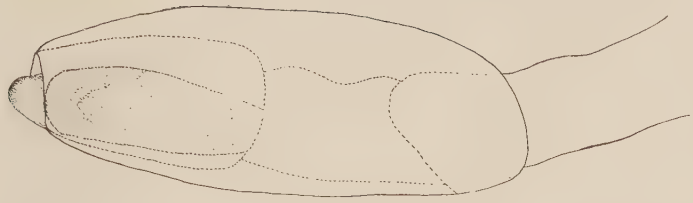
PLATE VII



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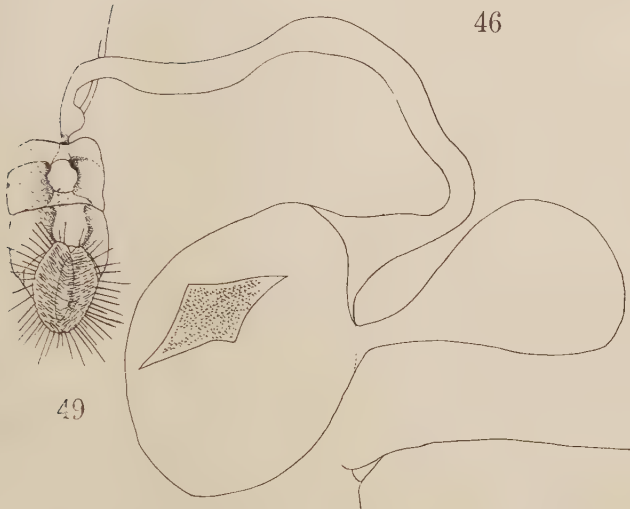

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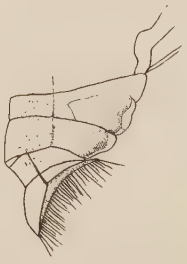

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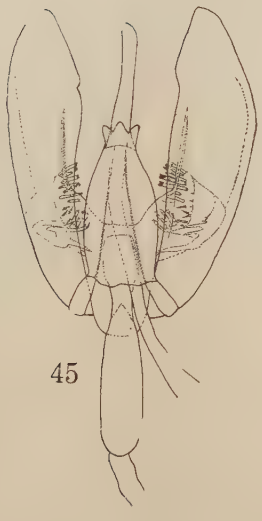

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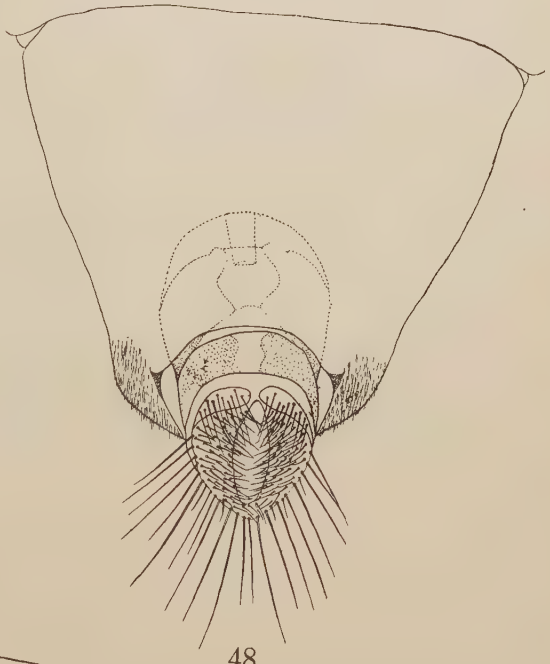

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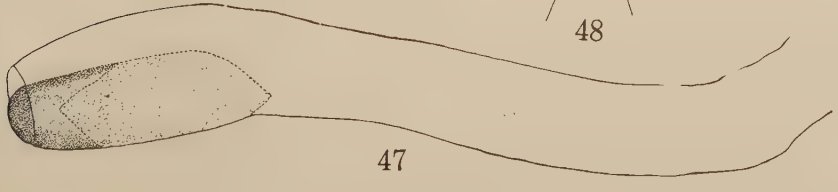

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Plate VIII

TABLE 1

bilalis through nine generations (summary table) a

F FOURTH UM		DURATION OF FIFTH STADIUM			DURATION OF SIXTH STADIUM			DURATION OF LARVAL STAGE			DURATION OF PUPAL STAGE			LENGTH OF TIME FROM EGG TO EMERGENCE			LENGTH OF LIFE CYCLE (FROM EGG TO EGG)		
lin.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.
ays	days	days	days	days	days	days	days	days	days	days	days	days	days	days	days	days	days	days	days
3	6	4.63	3	6	13.68	11	19	33.95	30	41	9.70	8	12	49.15	45	55	49.7	48	53
3	6	5.00	4	7	11.83	6	21	32.25	25	41	9.16	8	10	46.41	38	56	48.0	39	52
3	5	4.57	3	6	11.00	5	18	28.50	20	36	8.93	7	10	42.43	34	51	45.4	40	52
3	5	4.37	3	6	9.42	4	19	28.75	24	38	7.08	6	9	39.83	35	50	39.8	35	50
—	—	———	—	—	———	—	—	25.53	18	36	7.13	5	9	36.66	29	46	39.0	32	47
—	—	———	—	—	———	—	—	21.00	19	23	9.33	8	11	34.33	32	36	35.6	33	37
—	—	———	—	—	———	—	—	31.05	24	38	7.44	6	9	42.50	36	50	47.6	44	50
—	—	———	—	—	———	—	—	23.50	23	24	7.50	7	8	35.00	35	35	37.5	36	39
—	—	———	—	—	———	—	—	35.50	35	36	8.50	8	9	48.00	47	49	50.5	49	52
			3			4			18			5			29			32	
			7			21			41			12			56			53	
57			4.64			11.48			28.89			8.3			41.47			43.69	

partment of Entomology.

GENERATION	APPROXIMATE DATES COVERED	NUMBER OF INDIVIDUALS OBSERVED	INCUBATION PERIOD	DURATION OF FIRST STADIUM			DURATION OF SECOND STADIUM			DURATION OF THIRD STADIUM			DURATION O STADI	
				Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	M
			days	*days*	*days*	*days*	*days*	*days*	*days*	*days*	*days*	*days*	*days*	
First	29-X to 18-XII-1924	20	5	4.68	3	6	3.15	3	4	3.89	3	6	4.05	
Second	21-XII-1924 to 11-II-1925	12	5	3.58	2	5	4.00	3	5	3.66	3	4	4.16	
Third	2-II to 26-III-1925	14	5	2.79	2	3	2.79	2	4	3.86	3	6	3.50	
Fourth	21-III to 30-IV-1925	24	4	3.17	3	4	4.29	3	5	3.71	3	6	3.79	
Fifth	3-V to 20-VI-1925	30	4	———	—	—	———	—	—	———	—	—	———	
Sixth	4-VI to 11-VII-1925	6	4	———	—	—	———	—	—	———	—	—	———	
Seventh	7-VII to 26-VIII-1925	18	4	———	—	—	———	—	—	———	—	—	———	
Eighth	21-VIII to 7-X-1925	2	4	———	—	—	———	—	—	———	—	—	———	
Ninth	17-IX to 8-XI-1925	2	4	———	—	—	———	—	—	———	—	—	———	
Minimum		—	4	2			2			3			3	
Maximum		—	5	6			5			6			6	
Average		—	4.33	3.55			3.56			3.78			3	

[a] Abridged from seventeen tables, eleven of which were withdrawn from publication on account of length. Originals are on file in the De

TABLE 2

Number of copulations during life of female

SET I						SET II				
Confined male (♂) and female (♀)	Male and female separated			Total number of eggs laid during entire laying period	Fertile (f) or infertile (i)	Male and female confined	First oviposition	Male and female separated	Total number of eggs laid during entire laying period	Fertile (f) or infertile (i)
	Date	Remarks: Died (D) ♂	Remarks: Died (D) ♀							
1924	1924					1925	1925	1925		
29-X	6-XI	D	D	975	f	17-III	17-III	18-III	316	f
30-X	5-XI	D	—	620	f	18-III	18-III	19-III	339	f
30-X	9-XI	D	—	434	f	19-III	19-III	20-III	203	f
4-XI	10-XI	D	—	411	f	19-III	19-III	20-III	342	f
4-XII	10-XII	D	D	790	f	21-III	21-III	22-III	197	f
9-XII	11-XII	D	D	245	f	21-III	22-III	23-III	115	f
9-XII	16-XII	—	D	256	f	20-III	22-III	23-III	210	f
9-XII	23-XII	D	D	1061	f	28-III	28-III	29-III	433	f
10-XII	17-XII	D	—	218	f	29-III	29-III	30-III	416	f
12-XII	17-XII	D	—	581	f	29-III	29-III	30-III	872	f
14-XII	23-XII	—	D	519	f	1-IV	1-IV	2-IV	257	f
16-XII	19-XII	D	—	258	f	4-IV	5-IV	6-IV	433	f
16-XII	24-XII	—	D	436	f	3-IV	4-IV	5-IV	549	f
16-XII	21-XII	D	—	331	f	11-IV	14-IV	15-IV	527	f
16-XII	21-XII	—	D	198	f	11-IV	13-IV	14-IV	506	f
——	——	—	—	——	—	11-IV	14-IV	15-IV	647	f
——	——	—	—	——	—	21-IV	22-IV	23-IV	1193	f
Minimum		—	—	198	—	——	——	——	115	—
Maximum		—	—	1061	—	——	——	——	1193	—
Average		—	—	488.8	—	——	——	——	444.4	—

TABLE 3

Place of oviposition of the corn borer under natural condition

DATE COLLECTED	NUMBER OF EGGS IN MASS	LOCATION ON CORN PLANT		
		Leaf surface	Distance from the base of the leaf	Leaf number from the base of plant
1925			*cm.*	
1-III	21	nether	20.0	7
1-III	32	"	19.0	6
1-III	6	"	10.0	8
1-III	23	"	24.0	9
1-III	24	"	30.0	9
1-III	23	"	35.0	8
1-III	43	"	10.0	10
2-III	26	upper	22.0	7
2-III	24	nether	50.0	6
2-III	42	"	29.0	8
2-III	41	"	13.0	9
2-III	33	"	30.0	8
2-III	51	"	19.0	9
2-III	39	"	17.0	7
2-III	20	"	34.0	10
2-III	34	"	24.0	9
2-III	12	"	30.0	7
2-III	31	"	25.0	8
2-III	36	"	16.0	7
2-III	30	upper	27.0	8
2-III	20	nether	65.0	8
2-III	25	"	35.0	8
2-III	24	"	19.0	9
2-III	38	"	23.0	8
3-III	19	"	25.0	8
3-III	24	"	23.0	8
3-III	20	"	26.0	8
3-III	53	"	20.0	8
3-III	37	"	24.0	8
3-III	23	"	11.0	7
3-III	42	"	32.0	10
3-III	130	"	23.0	9
3-III	12	"	18.0	9
3-III	44	"	25.0	8
3-III	26	"	19.0	6
3-III	36	"	19.0	7
3-III	58	"	25.0	7
3-III	47	"	17.0	10
3-III	64	"	15.0	7
3-III	36	"	3.0	7
26-III	32	"	23.0	9
26-III	20	"	25.0	6
26-III	28	"	15.0	5
26-III	29	"	26.0	8
26-III	32	"	13.0	8
26-III	17	"	26.0.	6
26-III	61	"	75.0	6
26-III	25	"	21.0	8
26-III	39	"	30.0	6
26-III	60	"	13.0	8

26-III	19	"	25.0	7
26-III	35	"	27.0	7
26-III	52	"	33.0	7
26-III	55	"	26.0	7
26-III	64	"	22.0	7
26-III	43	"	34.0	8
26-III	26	"	22.0	8
26-III	56	"	29.0	9
26-III	23	"	18.0	9
26-III	65	"	17.0	7
26-III	24	"	23.0	9
26-III	35	"	50.0	8
26-III	44	"	30.0	7
26-III	35	"	32.0	10
26-III	42	"	34.0	8
26-III	45	"	46.0	5
26-III	19	"	32.0	8
26-III	48	"	33.0	10
26-III	35	upper	25.0	7
26-III	37	nether	29.0	7
26-III	27	"	34.0	7
26-III	43	"	19.0	10
26-III	38	"	32.0	6
26-III	38	"	38.0	7
26-III	27	upper	27.0	9
26-III	34	nether	11.0	8
26-III	66	"	28.0	7
26-III	19	"	28.0	7
Minimum	6	———	3.0	———
Maximum	130	———	75.0	———
Average	36.28	———	26.0	———

TABLE 4

Time from emergence of female to laying of first batch of eggs

CULTURE NO.	ADULTS EMERGED	FIRST EGGS LAID	TOTAL
	1924	1924	*days*
1	29-X	31-X	2
2	30-X	31-X	1
3	30-X	1-XI	2
4	4-XI	7-XI	3
5	4-XII	5-XII	1
6	8-XII	9-XII	1
7	8-XII	9-XII	1
8	9-XII	10-XII	1
9	10-XII	12-XII	2
10	12-XII	13-XII	1
11	14-XII	16-XII	2
12	15-XII	16-XII	1
13	16-XII	17-XII	1
14	15-XII	16-XII	1
15	16-XII	18-XII	2
	1925	1925	
16	16-III	17-III	1
17	17-III	18-III	1
18	18-III	19-III	1
19	18-III	19-III	1
20	19-III	21-III	2
21	20-III	22-III	2
22	20-III	22-III	2
23	27-III	28-III	1
24	28-III	29-III	1
25	28-III	29-III	1
26	31-III	1-IV	1
27	3-IV	5-IV	2
28	3-IV	4-IV	1
29	11-IV	14-IV	3
30	11-IV	13-IV	2
31	11-IV	14-IV	3
32	21-IV	22-IV	1
Minimum	———	———	1
Maximum	———	———	3
Average	———	———	1.5

TABLE 5

Longevity of adult females

CULTURE NO.	DATE EMERGED	DATE DIED	LONGEVITY
	1924	1924	*days*
1	29-X	6-XI	8
2	30-X	7-XI	8
3	30-X	12-XI	13
4	4-XI	11-XI	7
5	4-XII	10-XII	6
6	9-XII	11-XII	2
7	9-XII	15-XII	6
8	9-XII	23-XII	14
9	10-XII	21-XII	11
10	12-XII	26-XII	14
11	14-XII	23-XII	9
12	16-XII	23-XII	7
13	16-XII	23-XII	8
14	16-XII	24-XII	8
15	16-XII	21-XII	5
	1925	1925	
16	17-III	24-III	7
17	18-III	24-III	6
18	19-III	25-III	6
19	19-III	26-III	7
20	19-III	24-III	5
21	20-III	25-III	5
22	20-III	25-III	5
23	28-III	6-IV	9
24	29-III	4-IV	6
25	29-III	10-IV	12
26	31-III	5-IV	5
27	3-IV	10-IV	7
28	3-IV	9-IV	6
29	11-IV	27-IV	16
30	11-IV	26-IV	15
31	11-IV	30-IV	19
32	21-IV	1-V	10
Minimum	———	———	2
Maximum	———	———	19
Average	———	———	8.5

TABLE 6

Longevity of adult males

CULTURE NO.	DATE EMERGED	DATE DIED	LONGEVITY
	1924	1924	*days*
1	29-X	6-XI	8
2	30-X	5-XI	6
3	30-X	9-XI	10
4	4-XI	10-XI	6
5	4-XII	10-XII	6
6	9-XII	11-XII	2
7	9-XII	17-XII	8
8	9-XII	23-XII	14
9	6-XII	17-XII	11
10	12-XII	17-XII	5
11	14-XII	24-XII	10
12	14-XII	19-XII	5
13	16-XII	25-XII	9
14	16-XII	21-XII	5
15	16-XII	23-XII	7
	1925	1925	
16	17-III	21-III	4
17	18-III	23-III	5
18	16-III	23-III	7
19	16-III	21-III	5
20	20-III	25-III	5
21	20-III	25-III	5
22	20-III	25-III	5
23	28-III	5-IV	8
24	29-III	14-IV	16
25	29-III	12-IV	14
26	2-IV	9-IV	7
27	2-IV	7-IV	5
28	3-IV	8-IV	5
29	11-IV	27-IV	16
30	11-IV	27-IV	16
31	11-IV	27-IV	16
32	21-IV	7-V	16
Minimum	———	———	2
Maximum	———	———	16
Average	———	———	8.34

TABLE 7

Period of fecundity

CULTURE NO.	FIRST EGGS LAID	LAST EGGS LAID	TOTAL
	1924	1924	*days*
1	31-X	5-XI	5
2	31-X	5-XI	5
3	1-XI	10-XI	9
4	7-XI	9-XI	2
5	5-XII	9-XII	4
6	9-XII	10-XII	1
7	9-XII	13-XII	4
8	10-XII	19-XII	9
9	12-XII	20-XII	8
10	13-XII	22-XII	9
11	16-XII	22-XII	6
12	16-XII	21-XII	5
13	17-XII	23-XII	6
14	16-XII	23-XII	7
15	18-XII	19-XII	1
	1925	1925	
16	17-III	23-III	6
17	18-III	22-III	4
18	19-III	23-III	4
19	19-III	23-III	4
20	21-III	24-III	3
21	22-III	24-III	2
22	22-III	24-III	2
23	28-III	4-IV	7
24	29-III	3-IV	5
25	29-III	6-IV	8
26	1-IV	3-IV	2
27	5-IV	8-IV	3
28	4-IV	8-IV	4
29	14-IV	26-IV	12
30	13-IV	22-IV	9
31	14-IV	25-IV	11
32	22-IV	29-IV	7
Minimum	———	———	1
Maximum	———	———	12
Average	———	———	5.43

TABLE 8

Time from laying of last eggs to death of female

CULTURE NO.	LAST EGGS LAID	DEATH OF FEMALE	TOTAL
	1924	1924	*days*
1	5-XI	6-XI	1
2	5-XI	7-XI	2
3	10-XI	12-XI	2
4	9-XI	11-XI	2
5	9-XII	10-XII	1
6	10-XII	11-XII	1
7	13-XII	15-XII	2
8	19-XII	23-XII	4
9	20-XII	21-XII	1
10	22-XII	26-XII	4
11	22-XII	23-XII	1
12	21-XII	23-XII	2
13	23-XII	24-XII	1
14	23-XII	24-XII	1
15	19-XII	21-XII	2
	1925	1925	
16	23-III	24-III	1
17	22-III	24-III	2
18	23-III	25-III	2
19	23-III	26-III	3
20	24-III	24-III	0
21	24-III	25-III	1
22	24-III	25-III	1
23	4-IV	6-IV	2
24	3-IV	4-IV	1
25	6-IV	10-IV	4
26	3-IV	5-IV	2
27	8-IV	10-IV	2
28	8-IV	9-IV	1
29	26-IV	27-IV	1
30	22-IV	26-IV	4
31	25-IV	30-IV	5
32	29-IV	1-V	2
Minimum	———	———	0
Maximum	———	———	5
Average	———	———	1.94

TABLE 9

d by each female daily and total

DATE	CULTURES													DATE	CULTURES			
	XVI	XVII	XVIII	XIX	XX	XXI	XXII	XXIII	XXIV	XXV	XXVI	XXVII	XXVIII		XXIX	XXX	XXXI	XXXII
1925														1925				
17–III	65	—	—	—	—	—	—	—	—	—	—	—	—	13–IV	—	30	—	—
18–III	77	69	—	—	—	—	—	—	—	—	—	—	—	14–IV	100	72	159	—
19–III	81	91	67	93	—	—	—	—	—	—	—	—	—	15–IV	105	117	32	—
20–III	23	77	46	156	—	—	—	—	—	—	—	—	—	16–IV	89	60	151	—
21–III	26	64	34	58	142	—	—	—	—	—	—	—	—	17–IV	80	61	15	—
22–III	27	38	35	9	36	62	122	—	—	—	—	—	—	18–IV	46	57	87	—
23–III	17	0	21	26	0	37	64	—	—	—	—	—	—	19–IV	0	36	80	—
24–III	D	D	0	0	D-19	16	24	—	—	—	—	—	—	20–IV	66	27	32	—
25–III			D	0		D	D	—	—	—	—	—	—	21–IV	0	26	40	—
26–III				D				—	—	—	—	—	—	22–IV	4	20	35	227
27–III								—	—	—	—	—	—	23–IV	0	0	0	259
28 III								102	—	—	—	—	—	24–IV	4	0	0	295
29–III								93	44	214	—	—	—	25–IV	27	0	16	181
30–III								60	130	150	—	—	—	26–IV	6	D	0	70
31–III								0	124	190	—	—	—	27–IV	D		0	87
1–IV								0	24	96	35	—	—	28–IV			0	59
2–IV								0	0	111	126	—	—	29–IV			0	15
3–IV								128	94	0	96	—	—	30–IV			D	0
4–IV								50	D	25	0	—	151	1–V				D
5–IV								0		44	D	128	124					
6–IV								D		42		165	154					
7–IV										0		0	0					
8–IV										0		140	120					
9–IV										0		0	D					
10–IV										D		D						
	17	38	21	9	0	16	24	0	0	0	35	0	0		0	20	0	15
	81	91	67	156	142	62	122	128	130	214	126	165	154		105	117	159	295
	45.1	67.8	40.6	68.4	49.2	38.3	70	54.1	69.3	96.9	85.6	108.2	109.8		40.5	50.6	53.9	149.1
	316	339	200	342	197	115	210	433	416	872	257	433	549		527	506	647	1193

DATE	CULTURES				DATE	CULTURES										
	I	II	III	IV		V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV
1924					1924											
31–X	99	189	—	—	5-XII	147	—			—	—			—		
1–XI	290	202	145	—	6-XII	151	—			—						
2–XI	281	125	75	—	7-XII	314	—			—						
3–XI	151	47	70	—	8-XII	103	—	—								
4–XI	106	0	66	—	9-XII	75	124	63								
5–XI	48	57	0	—	10-XII	D	121	52	365	—	—					
6–XI	D	0	59	—	11-XII		D	52	183	—						
7–XI		D	0	183	12-XII			75	65	14	—	—				
8–XI			0	133	13-XII			14	46	0	36	—	—			
9–XI			11	95	14-XII			0	133	32	108	—	—	—	—	—
10–XI			8	0	16-XII			D	94	0	176	—	—	—	—	—
11–XI			0	D	16-XII				70	53	86	184	89	—	52	—
12–XI			D		17-XII				56	22	58	84	36	38	30	—
					18-XII				36	10	45	94	0	109	53	180
					19-XII				13	18	0	52	0	116	65	18
					20-XII				0	69	25	49	83	35	50	0
					21-XII				0	D	25	22	50	58	21	D
					22-XII				0		22	34	0	38	24	
					23-XII				D		0	D	D	42	36	
					24-XII						0			D	D	
					25-XII						0					
					26-XII						D					
Min., daily..	48	0	0	95		75	121	14	13	0	0	22	0	35	21	18
Max., daily..	290	202	145	183		314	124	75	365	69	176	184	89	116	65	180
Ave., daily..	162.5	103.3	43.4	137		158	122.5	51.2	106.1	24.2	58.1	74.1	43	62.3	41.4	99
Total..	975	620	434	411		790	245	256	1061	218	581	519	258	436	331	198

TABLE 10

Dates of initial infestation, degrees, and ages of susceptibility of the corn plant

DATE OF INITIAL INFESTATION	SUSCEPTIBLE AGE OF THE CORN PLANT	DEGREE OF INFESTATION AS DETERMINED ON HARVESTING	LOCALITY
1924	*Stages*	*Percent*	
Oct. 4	From tasseling to glazing[a]	80	Anos, Los Baños
Oct. 6	" " "	80	Anos, Los Baños
Dec. 15	" " "	75	San Antonio, Los Baños
1925			
Jan. 1	" " "	60	San Antonio, Los Baños
Jan. 9	" " "	60	San Antonio, Los Baños
Jan. 15	" " "	60	South of Animal Husbandry building
Jan. 28	" " "	70	East of the hill in the Experiment Station
Jan. 28	" " "	60	San Antonio, Los Baños
Feb. 2	" " "	50	Copeland Heights
Feb. 5	" " "	60	Animal Husbandry (near the hill)
Feb. 14	" " "	70	Anos, Los Baños
Feb. 15	" " "	50	East of the hill in the Experiment Station
Feb. 15	" " "	60	East of the hill in the Experiment Station
Feb. 15	" " "	5	Copeland Heights
Feb. 17	" " "	7	Animal Husbandry (lot near hill)
March 1	" " "	50	Back of Auditorium
March 7	" " "	98	Back of Protestant Chapel
June 8	From before tasseling to glazing	50	Animal Husbandry (near hill)
July 1	From tasseling to glazing	60	Animal Husbandry (near hill)
July-Sept.	" " "	90	Between Chemistry building and Auditorium
Sept. 6	" " "	80	Near Auditorium
1926			
Jan. 1	" " "	5	Near Y. M. C. A. building
Jan. 15	" " "	2	Maajas, Los Baños
Jan. 16	" " "	2	Bay, Laguna
March 18	" " "	6	Animal Husbandry (lot near hill)
March 19	" " "	8	Animal Husbandry (near Poultry House)
April 10	" " "	98	Near Poultry House
July 10	" " "	86	Experiment Station
July 18	" " "	6	Near Main Building (C. A.)
July 22	" " "	50	Near Y. M. C. A. building
Aug. 22	" " "	70	Near Y. M. C. A. building
Sept. 13	" " "	80	Experiment Station
Oct. 16	" " "	70	Experiment Station
Nov. 10	" " "	50	San Antonio, Los Baños
Dec. 10	" " "	30	San Antonio, Los Baños
Dec. 10	" " "	10	San Antonio, Los Baños
Dec. 26	" " "	20	San Antonio, Los Baños

[a]Ears at stage suitable for roasting.

TABLE 11

Natural enemies of Pyrausta nubilalis Hübn. in the Philippines

ACC. NO.	STAGE PARASITIZED OR PREYED UPON	SCIENTIFIC NAME	FAMILY	ORDER
Ec 186	Larva		Braconidae	Hymenoptera
Ec 187	"	Chelonus communis Baker (MS).....	Braconidae	Hymenoptera
Ec 196	"	Xanthopimpla stemmator[a].....	Ichneumonidae	Hymenoptera
Ec 195	"		Chalcididae	Hymenoptera
Ec 197	"		Ichneumonidae	Hymenoptera
Ec 198	"		Ichneumonidae	Hymenoptera
Ec 188	Pupa	Chalcis euploeae Hope[b].....	Chalcididae	Hymenoptera
Ec 189	"		Chalcididae	Hymenoptera
Ec 361	"		Ichneumonidae	Hymenoptera
Ec 190	Larva	Phemius tibialis Westwood.....	Harpactoridae	Hemiptera
Ec 192	"	Proreus simulans Stal.	Chelisochidae	Dermaptera
Ec 191	Larva and pupa	Sphodronyttus erythropterus Burm.	Harpactoridae	Hemiptera
Ec 193	" " "		Formicidae	Hymenoptera
Ec 194	" " "	Carpophilus fovelcollis Murr.	Histeridae	Coleoptera

[a]Determined by R. A. Cushman

[b]Determined by C. F. Baker

STUDIES ON THE GERMINATION OF VEGETABLE SEEDS[1]

GAUDENCIO A. VENTURA

INTRODUCTION

Knowledge of effective methods of germinating vegetable seeds is valuable in truck gardening. Seeds of valuable plants are often lost or spoiled by attempting to germinate them in unsuitable soil or in soil containing an excessive or insufficient amount of water,—conditions which invariably produce poor results.

The present study deals with the germination of some vegetable seeds in soil with different moisture content. Only the two kinds of soil, sand and garden loam, that are most commonly used in germinating vegetable seeds in the Philippines were employed. These soils were compared as to their relative suitability as media for the germination of vegetable seeds. Attempts were made to determine the optimum amount of water that each of these soils should contain to produce not only the highest percentage, but also the most rapid germination of each kind of vegetable seeds studied.

No published account of studies on this subject in the Philippines is available. The Philippine literature on vegetable seeds deals for the most part with the germination of seeds as influenced by chemicals, soaking previous to germination, etherization, etc.,—topics which are not part of the present study. Hence, it was deemed advisable not to include citations from these studies in the present report.

Objects of this study

The present study was conducted with the objects: (*a*) to determine the relative suitability of garden loam and sand for the germination of vegetable seeds; (*b*) to determine how much water garden loam or sand should contain in order to produce a rapid and a high percentage of germination, and (*c*) to determine the rate and percentage of germination of vegetable seeds as influenced by the presence or absence of oxygen in air.

Time and place of this study

This study was carried out in the Department of Plant Physiology of the College of Agriculture, Los Baños, Laguna. The experiments were started some time in April, 1926 and were continued at irregular intervals until May, 1927.

[1] Thesis presented for graduation, 1928, with the degree of Bachelor of Agriculture from the College of Agriculture No. 276; Experiment Station contribution No. 564. Prepared in the Department of Plant Physiology under the direction of Dr. Rafael B. Espino.

MATERIALS AND METHODS

The seeds

In the present study nine kinds of vegetable seeds were used.

1. Pechay, *Brassica cernua* (Thumb.) Forbes & Hemsl.
2. Mustard, *Brassica integrifolia* (West) O. E. Schulz.
3. Cabbage, *Brassica oleracea* Linn.
4. Radish, *Raphanus sativus*, Linn.
5. Beet, *Beta vulgaris* Linn.
6. Lettuce, *Lactuca sativa* Linn.
7. Pepper, *Capsicum annum* Linn.
8. Tomato, *Lycopersicum esculentum* Mell.
9. Eggplant, *Solanum melongena* Linn.

The cabbage, pechay, and radish seeds were obtained from the Liu-Paw-Cheng & Co., Manila; the eggplant, tomato, pepper and beet seeds from the Bureau of Agriculture, Manila; the lettuce and mustard seeds from the Agronomy Department of the College of Agriculture, Los Baños.

Only sound seeds of each kind, apparently uniform in size were selected. Seeds that were very small or light, and those bearing signs of injury from the attack of either insects or fungal parasites were discarded.

The soils

Sand and garden loam soil were used for this study. They were taken from the Nursery ground of the College. The sand was brought originally from a river bank in Bay, Laguna.

The garden loam soil was pulverized into fine particles. To obtain particles as uniform in size as possible, the two soils were sieved separately through meshes of about one millimeter in diameter. After sifting, the soils were sterilized at a temperature of 100°C. This precaution was taken so as to be reasonably sure that fungal or micro-organisms that might have been in the soils were killed.

Moisture contents of media

Beakers with a capacity of 400 cc. were used as germination receptacles. The weight of each beaker was determined, then 300 grams of sand were put into each. The weight of each beaker and of the sand it contained together with the weight of the moisture in the sand formed the initial weight of a germinator. Other germination receptacles were likewise prepared. In these receptacles, ordinary garden loam soil was placed. The germinators were grouped into lots of ten. Each lot was treated in such a way that the soil in the first beaker had 100 per cent of water saturation; the second, 90; the third, 80; the fourth, 70; the fifth, 60; the sixth, 50; the seventh, 40; the eighth, 30; the ninth, 20 and the tenth, 10.

In determining the percentage of water saturation of a soil, 300 grams of the soil were put in a glass funnel. Tap water of known amount was

poured into it, catching the excess amount in a beaker. In a saturated condition, the soil was considered to be at 100 per cent saturation. In order to know the exact amount of water present in the soil with 100 per cent saturation, the excess amount of water collected was subtracted from the original amount of water poured into the funnel, the difference was added to the amount of water found in the soil, which amount was previously determined with the use of the usual drying method. The 90 per cent water saturation was obtained by adding to the given quantity of soil, 90 per cent of the amount of water that gave 100 per cent water saturation. The other percentages of saturation down to 10 per cent were determined. This procedure was followed in determining the different degrees of water saturation of each of the two soils (sand and garden loam).

Germinating the seeds

Fifty of the selected seeds were distributed on the surface of the soil in each germinator. Then the seeds were carefully covered with the soil to a depth of about five millimeters. The computed amount of water necessary to make 100 per cent moisture content was poured as evenly as possible on the surface of the soil in germinator 1; 90 per cent into germinator 2; and so on, down to 10 per cent. The moisture content in each germinator was kept constant throughout the period of experiment by adding water daily to replace the loss in weight by evaporation.

The germinators were provided with fairly tight cork stoppers which prevented rapid evaporation of water. There was, however, at the mouth of each beaker a little opening that permitted aëration. The rate of germination was noted every day until no sign of germination was seen. During the experiment the temperature of the air in the laboratory in which this work was conducted ranged from 25° to 34°C.

EXPERIMENTS AND RESULTS

The experiments performed in connection with this study were grouped into three main lots; namely, (1) germination in sand; (2) germination in garden loam soil; and (3) germination as influenced by presence and absence of oxygen in air.

Germination in sand

Seeds of pechay. On May 5, 1926 the first set of experiments on germination of pechay seeds in sand containing different amounts of moisture was started. The number of seeds that germinated in a day; the number of days that elapsed before germination started and the length of time required to obtain a "complete"[2] germination were observed and recorded. These data are on file in the Department of Plant Physiology in the Col-

[2] "Complete germination" is used in this paper to mean when no more seeds sprouted.

lege. The data on total germination obtained are recorded as set I, in the upper part of table 1.

Similar experiments were conducted beginning on April 14, 1927. This time, the cultures were run in triplicates; so that three sets of data were obtained. These data are also recorded in table 1 as set II, set III, and set IV.

Seeds of lettuce. The first set of experiments on germination of seeds of lettuce was started on May 19, 1926. In order to obtain data under the same criteria of results employed with pechay seeds, daily observations on the germination of the seeds of lettuce were made. The data thus gathered are not here published but the total percentages of germination are shown as set I, in table 1. These experiments were repeated in three similar sets beginning on April 14, 1927. The results obtained as totals are given also in table 1 as sets II, III, and IV.

Other seeds. With similar methods of germination and of gathering results used with pechay and lettuce seeds, the germination of other seeds were studied. The data obtained for the seeds of tomato, for eggplant, and for beets, are given in table 1.

Germination of seeds of mustard, cabbage, radish, and of pepper was also studied. The germination experiments conducted on each kind of seed were in three sets, (sets I, II and III) and the results, as total percentages of germination of these seeds are shown in table 1.

Germination in garden loam soil

Experiments with this soil were started in a manner similar to that used with sand. The number of seeds that germinated every day in this soil was counted. The number of days that elapsed before the seeds began to germinate and the length of time required in order to have a complete germination were noted and recorded. These data are on file. The total percentage of germination of the seeds of pechay, lettuce, tomato, eggplant and of beets are shown in table 1. Seeds were considered to have germinated when they developed radicles and plumules.

Germination as influenced by presence or absence of oxygen in air

An apparatus consisting of a bell jar connected to a series of bottles containing pyrogallic acid solution on one side, and to an aspirator on the other, was set up. Fifty seeds, of each of pechay, mustard, lettuce, cabbage, beets, radish, tomato, eggplant, and pepper, after soaking them in water, were placed separately on a germinating bed made of moistened cotton. This seed bed was put on a platform and placed under the bell jar. To absorb any oxygen gas that might be present in the jar, two beakers containing a strong solution of pyrogallic acid were placed under the bell jar. This preparation is here designated as the test.

Another apparatus similar to the one just described was set up. In this one, pyrogallic acid was not used. This preparation served as the control.

The test and the control were placed side by side and were run or started simultaneously. The fine jets of the aspirators, which permitted and regulated the flow of an equal amount of water were opened at the same time. The water from the aspirators flowed through the jets, and a continuous current of air from the outside of the bell jar was sucked or drawn into the system by replacement process. The drawing of atmospheric air into the system was made possible by making the whole apparatus air-tight, save the opening through which the air entered. The air that entered the test apparatus was freed of its oxygen by subsequent passage through the series of bottles which contained a strong solution of pyrogallic acid. Hence, the air that reached the seeds in the bell jar was practically free from oxygen. In the case of the control apparatus, the air that reached the seeds under the bell jar contained oxygen, since the series of bottles through which it passed did not contain any pyrogallic acid solution. In other words, the test and the control differed in that the germinating seeds in the test was provided with oxygen-free air; while those in the control were supplied with air with the usual amount of oxygen.

For 11 days, the daily rate of germination in each set was noted. The period of observation was of this duration because, according to the results in the early part of this study, it took even less than 11 days for the complete germination of any of the seeds to be attained.

Three trials were made for this study. The data obtained as total percentage of germination of the seeds are shown in table 2.

DISCUSSION OF RESULTS

Rates and percentages of germination

To make the presentation of results clear and concise, the data gathered on the rates and percentages of germination of the vegetable seeds tested will be discussed separately.

Pechay seed. The seeds of pechay began to germinate three days after sowing in sand. In fact, most of the seeds germinated on the third and fourth days. Sprouting, however, continued until the sixth or seventh day, after which time no further germination occurred.

It is shown in table 1 that the seeds of pechay were able to germinate in sand containing from 20 to 100 per cent saturation. The best result, however, was obtained from the pot containing 90 per cent saturation, which gave an average of 93 per cent germination. Sand containing 80 per cent saturation was also found to be quite a satisfactory medium for germination of pechay seeds.

In ordinary garden loam soil, the highest percentage of germination (table 1) was also obtained from the germinator which was supplied with

90 per cent saturation. Eighty per cent saturation was also found to have given a fairly satisfactory result.

Lettuce seeds. The seeds of lettuce germinated in sand with moisture content ranging from 30 to 100 per cent saturation (table 1). From three out of the four sets of tests made, 90 per cent saturation was found to be the best. As the degree of saturation was decreased, there was a corresponding decrease in germination. The converse was also true; for in 100 per cent saturation there was a decrease in the percentage of germination of the seeds sown in three sets of tests or cultures.

As in the case of pechay seeds, the seeds of lettuce began to germinate three days after sowing and highest percentages of germination were obtained three or four days after sowing the seeds. Seven to nine days after sowing, germination of the seeds was found to be complete.

Of the different degrees of saturation tested, the garden loam soil was found most suitable for germination at 90 per cent saturation. As the moisture content was decreased or increased, there was a corresponding decrease in germination. Germination of the seeds of lettuce was found complete eight to nine days after sowing.

Tomato seeds. The seeds of tomato required four to five days to start germinating which was a little longer than either the seeds of pechay or of lettuce needed. Five or six days from the day seeds began to show signs of activity, germination was found to be complete. Under different culture media employed, the highest percentages of germination were obtained six to seven days after sowing the seeds. The highest success in germination was obtained from the sand containing 90 per cent saturation. As the moisture content of the medium was increased or decreased there was a corresponding decrease in percentage of germination of the seeds of tomato. A few seeds were found able to germinate even when the moisture content of the sand was as low as 20 per cent.

In garden loam soil (table 1), the highest percentage of germination of the seeds of tomato was obtained when the soil was supplied with 90 per cent water saturation. With 100 per cent saturation, germination was decidedly low; the 80 per cent saturation proved fairly satisfactory.

Eggplant seeds. In sand, seeds began to germinate about four days after sowing. Nine to ten days later, germination was found complete. Most of the seeds germinated in sand containing different moisture content, five to six days after sowing. The two highest records on germination of the seeds of eggplants were obtained from the media which had 90 and 80 per cent water saturation.

In garden loam soil, the 90 and the 80 per cent saturation were also found to give the two highest percentages of germination and most of the seeds germinated five days after sowing.

Beet seeds. The highest percentage of germination of the beet seeds was obtained when the sand in the pots was with 90 per cent saturation.

This statement is borne out by the results obtained from the four sets of tests. Sand soil with the 100 per cent saturation was likewise very suitable for the germination of beet seed. Although seeds began to sprout five days after sowing, most of them sprouted six to seven days after planting. Seeds continued to germinate daily but at irregular rates and the germination was found to be complete after about eleven days.

In garden loam soil, seeds of beet began to germinate five days after sowing. The process continued up to eight or nine days, though by this time, very few seeds germinated. Beet seeds were found tolerant of rather large amounts of water in the soil. Extremely poor germination of beet seeds was found when the soil had 30 per cent saturation. With 20 per cent saturation or lower no seeds germinated (table 2).

Mustard seeds. Three days after sowing, mustard seeds began to germinate. On the sixth day, only a few seeds germinated, and on the seventh, none. With the 90 per cent saturation, the highest record on germination of this kind of seeds was obtained. As the moisture content of the soil decreased there was a corresponding decrease in the rate of germination. With 100 per cent saturation, germination was found to be fairly satisfactory (table 2).

Cabbage seeds. In sand, cabbage seeds began to germinate three days after sowing, after the fifth day, none germinated. Under the different degrees of water saturation of the soil media, it was found that most of the seeds sprouted three to four days after sowing. The highest percentage of germination undoubtedly was obtained from the soil which had 90 per cent saturation. Germination was decidedly poor when the moisture content in the soil was either increased or decreased (table 2).

Radish seeds. Of all the vegetable seeds tried, radish seeds were the most exacting. They could not germinate unless the sand had at least 40 per cent water saturation. Even with this moisture content only a few seed germinated. The best result on germination was obtained when the soil had 90 per cent saturation. As the moisture content of the pot was increased or decreased there was a corresponding marked decrease in the number of the seeds that germinated (table 2).

Pepper seeds. As with the seeds of radish, the pepper seeds were rather exacting in moisture requirement. They could not germinate unless the sand had at least 40 per cent saturation. And, even with this degree of saturation, only very few seeds germinated. Of the three sets of test cultures tried, the germinator with 90 per cent saturation proved the most efficient in germination. As a whole, the seeds of pepper were rather slow in germinating. Seven to eight days were required to complete germination. There was not a single day in which most of the seeds germinated.

Sand and garden loam soils compared as germinating media for vegetable seeds

In making the comparison on the relative suitability of sand and of garden loam soil as solid media for the germination of the vegetable seeds,

care was taken to compare the data on germination obtained at the same time from these two kinds of soil.

As shown by the germination data for pechay, for lettuce, for tomato, for eggplant, and for best seeds (sets I in table 1 for both sand and garden loam soils), it was sufficiently demonstrated that as a solid medium for germination of these five kinds of vegetable seeds the sand is superior to the garden loam.

By casual observation it was found that more root hairs were produced by the seedlings grown in the sand than by those in the garden loam. This difference probably may be due to the looseness of the particles of sand which encourages the seedlings to produce numerous root hairs which increase the firm anchorage of the seedlings in the soil. It was noted in both the sand and garden loam that as the moisture content decreased the number of root hairs increased. Also, more root hairs were produced in the early than in the later stage of germination, an observation which corroborates the finding of Haberblandt (1914).[3]

Oxygen requirements of vegetable seeds during germination

As was expected, the absence of oxygen from the air or the presence of this element in insufficient amount affected germination of most of the vegetable seeds tested. The seeds which were supplied with the ordinary air (air with oxygen) invariably had much higher percentages of germination than those that were subjected to the influence of oxygen free air, (table 2). Oxygen, therefore, is essential for the normal germination of all the vegetable seeds tested. In passing, it may be said that the seedlings under the direct influence of ordinary atmospheric air generally had longer and larger stems than those of the seedlings grown in the presence of air supposedly oxygen. These seedlings looked sickly. In fact, the tops of the beet seedlings curled and dried up.

SUMMARY AND CONCLUSIONS

1. In both the sand and the garden loam soil, the seeds of pechay, lettuce, cabbage, and mustard began to germinate on the third day after sowing; those of pepper, radish, and eggplant on the fourth day and those of tomato and beets on the fifth day.

2. The highest percentages of germination of the seeds of pechay, lettuce, cabbage, radish, pepper, eggplant, and tomato, were obtained from sand with 80 to 90 per cent water saturation; 90 to 100 per cent saturation was found the most suitable for beets and mustard seeds.

3. Garden loam soil with 80 to 90 per cent saturation was found to be best suited for the germination of seeds of pechay, lettuce, tomato, and

[3] Haberblandt, C. 1914. Physiological plant anatomy. xv+777 p., 291 fig. London: The Macmillan Company, Ltd.

eggplant. For beet seeds the best results were obtained with 90 to 100 per cent saturation.

4. A few seeds of pechay were able to germinate in sand with as low as 10 per cent water saturation. Some seeds of tomato, eggplant, mustard, and cabbage germinated with saturation as low as 20 per cent. Seeds of lettuce and beets were sensitive; some were able to germinate in sand only when water saturation was at least 30 per cent Seeds of radish and pepper were still more sensitive; few were able to germinate in sand with as low as 40 per cent saturation.

5. Sand soil was found to be a better solid medium for germination of all the vegetable seeds studied than garden loam soil.

6. Invariably, the germination of any of the vegetable seeds studied was markedly checked, and the young plants were markedly stunted in growth, when supplied with air without oxygen or with oxygen in insufficient amounts.

TABLE 1

Percentage germination of vegetable seeds in two kinds of soil containing different amounts of water

KIND OF SEED	GERMINATION IN SAND											GERMINATION IN GARDEN-LOAM									
	Set	Percentage of water saturation										Set	Percentage of water saturation								
		100	90	80	70	60	50	40	30	20	10		100	90	80	70	60	50	40	30	20	10
Pechay....	I	74	91	92	70	60	50	44	34	22	12											
	II	84	92	88	80	78	62	62	28	12												
	III	80	96	92	92	84	76	72	12	6		I	62	90	76	72	62	52	44	30	20	6
	IV	82	94	84	84	80	68	68	62	26		II	82	94	94	84	78	70	56	46	34	14
	Average	80	93	89	82	76	64	62	34	17	3	Average	72	92	85	78	70	61	50	38	27	10
Lettuce....	I	40	60	46	44	26	26	20	10													
	II	68	70	64	58	54	44	38	12													
	III	70	76	62	58	36	34	32	20			I	30	66	48	42	22	22	14	10	2	
	IV	56	52	46	16	10	6	4	2			II	40	62	58	54	40	34	26	12	12	
	Average	59	65	55	44	32	28	24	11			Average	35	64	53	43	31	28	20	11	7	
Tomato...	I	50	72	68	62	60	54	52	48	10												
	II	58	82	64	60	56	50	44	38	24												
	III	42	66	54	56	56	42	36	36	12		I	10	62	58	58	56	52	46	36	26	
	IV	46	72	72	68	54	50	44	38	16		II	28	54	52	44	42	42	36	24	12	
	Average	49	73	65	62	57	49	44	40	16		Average	19	58	55	51	49	47	41	30	19	
Eggplant..	I	80	84	86	86	68	54	42	32	10												
	II	76	84	90	86	78	62	40	40	28												
	III	70	92	78	76	64	60	54	46	18		I	62	74	70	66	60	52	40	36	16	
	IV	68	82	72	70	58	54	48	34	12		II	70	84	80	78	70	58	50	40	22	
	Average	74	86	82	80	67	58	47	38	17		Average	66	79	75	72	65	55	45	38	19	
Beets.....	I	60	66	52	34	26	24	18	18													
	II	68	76	60	56	52	46	40	14													
	III	66	72	62	58	44	38	20	16			I	54	56	46	40	34	24	16	8		
	IV	60	54	50	46	40	32	14	10			II	66	56	42	42	38	36	16	10		
	Average	64	67	56	49	41	30	23	15			Average	60	56	44	41	36	30	16	9		
Mustard...	I	70	80	64	58	56	54	48	46	6												
	II	66	70	68	64	58	54	50	12	6												
	III	80	84	72	68	60	58	56	10	2												
	Average	72	78	68	63	58	55	51	23	5												
Cabbage...	I	40	82	64	54	42	30	18	12	8												
	II	52	80	48	42	36	24	12	6	4												
	III	36	76	54	50	44	30	12	4	2												
	Average	43	79	55	49	41	28	14	7	5												
Radish....	I	30	74	44	30	18	14	4														
	II	42	64	38	30	16	10	6														
	III	30	60	36	24	16	12	4														
	Average	34	66	39	28	17	12	5														
Pepper....	I	32	44	32	24	12	8	4														
	II	26	40	24	20	12	8	2														
	III	24	52	32	22	16	14	2														
	Average	27	45	29	22	13	10	3														

TABLE 2

Percentage germination of vegetable seeds as influenced by ordinary air and by oxygen-free air

SET	PECHAY		MUSTARD		LETTUCE	
	Ordinary air	Oxygen-free air	Ordinary air	Oxygen-ree air	Ordinary a r	Oxygen-free air
I	76	28	78	22	78	18
II	74	24	70	16	50	22
III	66	14	36	14	40	6
Average.	72	22	61	17	56	15

	CABBAGE		RADISH		BEETS	
	Ordinary air	Oxygen-free air	Ordinary air	Oxygen-free air	Ordinary air	Oxygen-free air
I	70	30	44	16	72	32
II	60	10	40	12	72	26
III	60	16	36	10	68	36
Average.	63	18	40	13	71	31

	TOMATO		PEPPER		EGGPLANT	
	Ordinary air	Oxygen-free air	Ordinary air	Oxygen-free air	Ordinary air	Oxygen-free air
I	48	12	30	14	32	10
II	46	4	30	8	32	8
III	54	10	26	12	20	2
Average.	49	9	29	11	28	7

NOTE: THE ECLIPSE OF MAY 9, 1929

The Manila correspondent of the *New York Sun* writes that a total eclipse of the sun will occur there on May 9, 1929, and the Hamburg Observatory has already arranged to have an observing party in the Philippines on that date. It is expected in Manila that other parties will come from the United States and Europe.

Full information was forwarded by Father Miguel Selga, S. J., director of the Philippine Weather Bureau and the Manila Observatory, to the astronomers' meeting in Leyden. Two factors warrant the expense of sending parties, Father Selga says, first, the great probability of clear weather, and second, the duration of the total eclipse over accessible and convenient observation points.

The plane of total eclipse extends across the middle islands of the Philippines, the Visayan group, through the tenth and two-thirds of the eleventh degrees of north latitude. On the western coast the duration of the total eclipse over this area will be 3 minutes 54.5 seconds; this in the vicinity of Dumaran Island, Palawan. On the eastern coast at good vantage points the duration will range between 3 minutes 42.3 seconds to 3 minutes 28.7 seconds. The longest duration of any eclipse is only about 7 minutes and such eclipses are infrequent, even speaking astronomically. There will be places outside the Philippines, in Sumatra and Siam, for example, where the eclipse may also be observed, and while Father Selga is little familiar with the accommodations that may be found there, he thinks some of the foreign parties may choose those points. He believes, however, that all American parties should choose the Philippines, to which end he has prepared the bulletin of information on living accommodations, sites, etc., appended to his scientific data.

He says that under no circumstances should astronomers be discouraged from trying to see the eclipse of May 9, 1929, in the Philippines. He has traced back the weather on May 9 at four convenient observation points during a period of twenty-five years and finds that the chances are very great that May 9 next year will be dry and clear. The date is prior to the change of the monsoon, and, while at that season of the year there are nearly always some clouds floating about during the day, at the afternoon hour of the eclipse the sky is almost certain to be clear. He selects eastern coast points, fronting the open sea. If there are clouds they will be hovering around the mountains to the west.

—*Science.*

ABSTRACT[1]

The relation of rainfall to the production of corn. Simplicio Tiglao. (*Thesis presented for graduation, 1928, from the College of Agriculture No. 277. Experiment Station contribution No. 565*).—The object of this work was to find out the relation of rainfall to corn production. This study was carried on from May 27, 1926 to April 11, 1927. Experimental plots of about 50 by 26 meters, located in the Experiment Station grounds of the College of Agriculture, were used. The lots were well suited to growing corn. Their preparation was uniform. Depth of planting, number of seeds in a hill (three), and distance between hills (one meter) were uniform in all plantings. After four weeks, each hill was thinned to two plants. When harvest was ready the ears in 100 hills picked at random were gathered, dried properly, and weighed. The plants at the edges of the plots were eliminated.

The record on rainfall was taken from the College data.

The results of this study show that there was better yield in the May and June plantings of Calauan and Baluga varieties than the yield of the same varieties in December. This was so because there was optimum amount of rain at the different stages of the plants of the May and June plantings, while there was a scarcity of rain during the vegetative and fruiting stages of the December planting. This shows the importance of effect of the distribution of rainfall.

In the Moro variety there were three plantings. The June planting gave the best yield, the July planting second, and the August planting the least. The first four weeks after the June planting there were 68.4 mm. of rainfall; the first four weeks of the July and August plantings were rainy. The rainfall in June was a good condition for growth, while that of July and August caused the rotting of the seeds and stunted the development of the seedlings. This shows that too much rain at the time of germination reduced the yield because there were missing hills and stunted development of the young plants.

—*Abstract by Severino L. Salvado.*

[1] Abstract prepared as part of required theme work in English 6, College of Agriculture.

EXTENSION DIVISION NOTES

(Reported by Mr. Moises M. Kalaw, Assistant in Extension Service.)

An Hacienda Worth Visiting

An hacienda in the Visayan Islands, which I visited I found very well worth seeing. This is Mr. Teofilo Mejia's hacienda at Puerto Bello, Ormoc, Leyte. It should be visited by those interested in Philippine agriculture. In this hacienda one can see what a paradise a Philippine farm can be made, if managed and developed properly. There are many fine haciendas in other provinces of the islands as in Negros, Iloilo, but the Mejia Hacienda is something quite different. Unlike other large haciendas which are mostly one-crop farms, the Mejia Hacienda is diversified, a type fitted to Philippine conditions. Besides the main crops which are corn, coconut, sugar cane, and abaca, there is a ranch, a pig project (with a pig pen very similar in plan to the one in our Animal Husbandry Department), a poultry project and a pigeon house. With such diversification the people living there buy nothing from the outside except clothing and a few luxuries. All the projects in that hacienda are well developed and managed, as if one well versed in the science of agriculture was at the head.

One can learn many things in this hacienda. It has a complete drainage system worth copying. The plan of the hacienda itself is exemplary. There is much to be learned from the coconut plantings and the hog projects. The coconut plantation is the cleanest private plantation I have ever seen. It is almost comparable in cleanliness to the Government plantation at San Ramon Penal Colony at Zamboanga, Mindanao.

It is the practice of the senior class of the Baybay Agricultural school to visit the Mejia Hacienda once a year. For instruction and observation it is well worth visiting by any one interested in agriculture. Students from the College of Agriculture who live near Leyte should try to visit this hacienda. It is a barrio about an hour by launch from Ormoc, a large town in Leyte.

Drying Problems in Leyte

While supervising the construction of a New College Copra Drier in Leyte, I had the chance to get first hand information regarding some of the farmer's problems from hacenderos who visited the drier. I learned that one of the agricultural problems in Leyte is the drying of coconut, corn, and rice early enough to prevent deterioration which causes heavy losses.

Farmers want drying devices. They were planning to use the New College Copra Drier with modification not only for copra but also for rice or corn. It may be possible to do this. The New College Copra Drier has

been tried for peanuts in Lipa, but it did not work, but it might if modified. A simple and cheap drier for drying rice or corn would be invaluable to Leyte farmers.

EXCHANGE NOTES

Democracy is an affair of the biologists and not the political scientists. This is the conclusion reached by Dr. Michael F. Guyer, head of the zoölogy department at the University of Wisconsin. For a democracy to survive, it must be carried on by a race having certain qualities of disposition, character and intellect. Because these things are inherited just as a man inherits physical characteristics, such as color of skin, hair and eyes, Dr. Guyer contends, the development of a race having the qualities necessary to operate a democracy successfully rests with the biologists.

—*Science.*

The cooperative movement in India is making comparatively rapid progress despite the many handicaps to be overcome, according to a statement issued by the department of commercial intelligence and statistics. At the end of 1926-27 the report shows that there were in India 89,071 societies with a membership of 3,422,000, and a total capital of 679,400,000 rupees.

—*Commerce Reports* (U.S.).

Much damage is caused to the rice crop in North Sind [India] by the formation of a thick layer of algae upon the water surface, if for any reason the water remains stagnant, as for example, where there is no natural fall in the level from field to field or again in low-lying places. It is comparatively rarely found where the water circulates freely from the higher field to the lower. Rain is also a preventive. This scum begins to develop soon after transplantation and in bad cases it increases until there is a thick green carpet resting upon the water surface, pierced only by the rice clumps. Gradually this scum tightens its grip round these clumps which becomes partially strangled and tillering is prevented.

The following treatment worked out on the Larkana Experimental Station has given excellent results. About 16 to 20 lb. (worth Rs. 12-8-0) of copper sulphate crystals per acre should be put in a cloth bag which is drawn through the field under the water surface so as to ensure uniform distribution.

Less quantities of copper sulphate will do if only a part of the field is covered by scum.

The scum dries up and settles leaving a clear water surface three to five days after the application of the treatment and *does not* reappear with subsequent irrigations.

—*The Agricultural Journal of India.*

The New England States have developed strains of the flint corns that give both yield and quality. They are beautiful ears. Most of their strains are of a bright amber color. The cob is usually white. When the corn is shelled it has a bright, attractive color. When cracked for chicken feed or when ground for meal, it is also attractive. Those who have used it for mush and for bread love it. It is so very hard that it needs to be cooked longer than does the softer dent corns. It has a small germ, and therefore, it yields but little oil as nearly all of the oil found in corn is contained within the germ. Those who grow accustomed to the western dent or corn belt type of corn, develop a distinct prejudice in favor of the dent corn, because of flavor that comes from the oil content, whereas, the up-state New Yorkers are equally favorable to their Yankee types of corn.

There is a great deal of interesting history attached to these different kinds of corn. The Indian developed the hard flint type mainly because he could adapt its habit of growth to suit his kind of farming. He had almost no implements or other farming equipment. He fashioned a sharp stick which the squaws used for planting corn. The sharp stick would open a hole four or five inches deep. The kernel was dropped into the hole deep enough to have moisture to carry it through a drouth period. It was deep enough to be out of reach of crows that seemed to have an uncanny sense of smell in locating planted kernels. They were known to rob a newly planted field, where shallow planting was practiced, and leave not enough kernels to grow. The Indians tried smelly fish oils for soaking the kernels, as a repellent for the crows. This was only partially successful. The deep planting caused the corn to develop a long cotyledon, which is the extension from the kernel to the new growth that gave the first pair of leaves. Some of these Indian developed types grow when planted as much as six inches deep.

—*California Cultivator.*

The task of studying the farm production of a state in relation to market demands and farm management practices properly belongs to the agricultural college. Some of our agricultural colleges are aggressive in meeting new conditions in agriculture. Others are less so. Farmers naturally look to their agricultural college for leadership, and this the college shoula be prepared to furnish. The policy of letting things drift in the hope that they may eventually right themselves is not a good one for an agricultural college to adopt.

—*The Prairie Farmer* (Illinois).

Three square chains of Uba and three square chains of ordinary cane were planted on the same kind of land and grown under same conditions in Jamaica.

The Uba cane when cut and ground yielded 31 pork barrels of liquor which gave 29 tins of sugar.

The ordinary cane yielded 15 barrels of liquor which gave 15 tins of sugar. The Uba sugar was slightly darker but both kinds sold in March for 8/ per tin.

Uba cane gave larger tonnage per acre, does not require so much cleaning as the ordinary cane, and is immune from Mosaic disease; rats leave it almost entirely alone and the native carriers do not eat it, or only very sparingly.

—*The Journal of the Jamaica Agricultural Society.*

COLLEGE AND ALUMNI NOTES

Dr. Regino R. Ylanan, National Secretary, Philippine Amateur Athletic Federation, and Alumni representative on the Board of Regents of the University of the Philippines, spoke at the students' convocation at the College of Agriculture Auditorium, October 31, 1928. The theme of Regent Ylanan's talk was the World's Olympiad at Amsterdam, Holland. He gave a vivid description of the classical event, and the representation the Philippines made.

A one hour lecture on algae, liverworts, mosses, and ferns was given by Dr. R. B. Espino to the class in biology of the Rizal High school that came to visit the College on October 27, 1928.

Dr. R. B. Espino gave a semi-popular lecture on "How A Plant Lives" to the members of the biology class of the Cavite High School in the College Auditorium on November 3, 1928.

Dr. C. E. Pemberton, the entomological member of the expedition sent last spring by the United States Department of Agriculture and the Hawaiian Sugar Planters Association to explore New Guinea for new varieties of sugar cane, in a letter to Professor Yule written from Port Moresby, New Guinea under date September 10 sums up the work thus:

I left Honolulu April 18th bound for New Guinea and have been here ever since and expect to stay perhaps a year longer.

Since arriving I have flown thousands of miles in a sea-plane we have for our expedition; have traveled by canoe hundreds of miles on the rivers, particularly the Fly River and have walked some 150 miles back in the mountains. We have collected considerably over 150 new varieties of sugar cane, some of which will very probably prove of great commercial value. . .

The expedition is now over without a mishap (malaria doesn't count). The party leaves here for U. S. A. in a few days. I will stay here to continue researches in insect parasitism.

Doctor Pemberton spent a year, 1925–26, on our Campus in research work for the Hawaiian Sugar Planters Association, using Mount Maquiling as a "source".

In his letter, Doctor Pemberton inclosed (unsolicited) a generous contribution for the Baker Memorial Fund.

Mr. Jose M. Capinpin, M. S. '23, who sailed in August for the United States, as U. P. Fellow, writes that he has registered in the Graduate School in Princeton University.

The luggage of the faculty and students now tells the world its owners are from the College of Agriculture. Attractive "stickers" are now on sale at Coop. These "stickers" are pennant shaped; green with "Agriculture" in gold (College colors); on the wide end is the U. P. seal in poinsetta red, ("U" color). These stickers are the result of Mr. Zosemo Montemayor's initiative.